NCCA

An Chomhairle Náisiúnta Curaclaim agus Measúnachta
National Council for Curriculum and Assessment

Draft Specification for Junior Cycle Science

This consultation is on the curriculum specification for Junior Cycle Science. Specifically, your views and observations on the draft introduction, rationale, aim, course overview, strands and learning outcomes for Junior Cycle Science are invited.

The specification also includes appendices containing *Examples of student work*, a *Glossary*, and *Work to date on potential assessment arrangements*. Consultation on the assessment for certification arrangements is deferred until discussions take place between the Minister for Education and Skills and the teacher unions in October.

September 2014

Contents

Introduction to junior cycle

Junior cycle education places students at the centre of the educational experience, enabling them to actively participate in their communities and in society, and to be resourceful and confident learners in all aspects and stages of their lives. Junior cycle is inclusive of all students and contributes to equality of opportunity, participation and outcome for all.

The junior cycle allows students to make a greater connection with learning by focusing on the quality of learning that takes place, and by offering experiences that are engaging and enjoyable for them, and are relevant to their lives. These experiences are of a high quality: they contribute directly to the physical, mental and social wellbeing of learners; and where possible, provide opportunities for them to develop their abilities and talents in the areas of creativity, innovation and enterprise. The junior cycle programme builds on students' learning to date and actively supports their progress; it enables them to develop the learning skills that will assist them in meeting the challenges of life beyond school.

Rationale

Science is a collaborative and creative human endeavour arising from our desire to understand the world around us and the wider universe. Essentially, it is curiosity in thoughtful and deliberate action. Learning science through inquiry enables students to ask more questions, and to develop and evaluate explanations of events and phenomena they encounter.

The study of science enables students to build on their learning in primary school and to further develop their knowledge of and about science. Students enhance their scientific literacy by developing their ability to explain phenomena scientifically; their understanding of scientific inquiry; and their ability to interpret and analyse scientific evidence and data to draw appropriate conclusions.

Developing scientific literacy is important to social development. As part of this process students develop the competence and confidence needed to meet the opportunities and challenges of senior cycle sciences, employment, further education and life. The wider benefits of scientific literacy are well established, including giving students the capacity to make contributions to political, social and cultural life as thoughtful and active citizens who appreciate the cultural and ethical values of science. This supports students to make informed decisions about many of the local, national and global challenges and opportunities they will be presented with as they live and work in a world increasingly shaped by scientists and their work.

Science is not just a tidy package of knowledge, nor is it a step-by-step approach to discovery. Nonetheless, science is able to promote the development of analytical thinking skills such as promoting problem-solving, reasoning, and decision-making. Learning science in junior cycle can afford students opportunities to build on their learning of primary science and to activate intuitive knowledge to generate, explore and refine solutions for solving problems. This may not always yield the expected result, but this, in turn, can be the focus for deeper learning and help the student to develop an understanding of risk and a realisation that different approaches can be adopted. As students develop their investigative skills, they will be encouraged to examine scientific evidence from their own experiments and draw justifiable conclusions based on the actual evidence. In reviewing and evaluating their own and others' scientific evidence and data, they will learn to identify limitations and improvements in their investigations. This collaborative approach will increase students' motivation, provide opportunities for working in groups and to develop the key skills of junior cycle.

In addition to its practical applications, learning science is a rewarding enterprise in its own right. Students' natural curiosity and wonder about the world around them can be nurtured and developed through experiencing the joy of scientific discovery.

The development of this specification has been informed by the eight principles for junior cycle education that underpin the *Framework for Junior Cycle*, all of which have significance for the learning of science as promoted by this specification.

Aim

Science in junior cycle aims to develop students' knowledge of and about science; to consolidate and deepen their skills of working scientifically; to make them more self-aware as learners and become competent and confident in their ability to use and apply science in their everyday lives.

More specifically it encourages all students

- to develop a sense of enjoyment in the learning of science, leading to a lifelong interest in science
- to develop scientific literacy and apply this in cognitive, affective and psychomotor dimensions to the analysis of science issues relevant to society, the environment and sustainability
- to develop a scientific habit of mind and inquiry orientation through class, laboratory and/or off-site activities that foster investigation, imagination, curiosity and creativity in solving engaging, relevant problems, and to improve their reasoning and decision-making abilities
- to develop the key skills of junior cycle, including literacy and numeracy skills: to find, use, manage, synthesise, evaluate and communicate scientific understanding and findings using a variety of media; and to justify ideas on the basis of actual evidence
- to acquire a body of scientific knowledge; to develop an understanding of Earth and space and their place in the physical, biological, and material world and to help establish a foundation for more advanced learning.

Overview: Links

The tables on the following pages show how junior cycle science is linked to central features of learning and teaching outlined in the *Framework for Junior Cycle*.

Table 1: Links between junior cycle science and the statements of learning

Statements of learning	
The statement	**Examples of relevant learning**
SOL 9. The student understands the origins and impacts of social, economic, and environmental aspects of the world around her/him.	Students will collect and examine data to make appraisals about ideas, solutions or methods by which humans can successfully conserve ecological biodiversity.
SOL 10. The student has the awareness, knowledge, skills, values and motivation to live sustainably.	Students will engage critically in a balanced review of scientific texts relating to the sustainability issues that arise from our generation and consumption of electricity.
SOL 13. The student understands the importance of food and diet in making healthy lifestyle choices.	Students will collect and examine evidence to make judgements on how human health can be affected by inherited factors and environmental factors, including nutrition and lifestyle choices.
SOL 15. The student recognises the potential uses of mathematical knowledge, skills and understanding in all areas of learning.	Students will participate in a wide range of mathematical activities as they analyse data presented in mathematical form, and use appropriate mathematical models, formulae or techniques to draw relevant conclusions.
SOL 16. The student describes, illustrates, interprets, predicts and explains patterns and relationships.	Through investigation, students will learn how to describe, illustrate, interpret, predict and explain patterns and relationships between physical observables.
SOL 17. The student devises and evaluates strategies for investigating and solving problems using mathematical knowledge, reasoning and skills.	Through planning and conducting scientific investigations, students will learn to develop their critical thinking and reasoning skills as they apply their knowledge and understanding to generate questions and answers rather than to recall answers.

SOL 18. The student observes and evaluates empirical events and processes and draws valid deductions and conclusions.	Students will engage in an analysis of natural processes: through observation and evaluation of the processes they will generate questions as they seek to draw valid deductions and conclusions.
SOL 19. The student values the role and contribution of science and technology to society, and their personal, social and global importance.	Students will research and present information on the contributions that scientists make to scientific discovery and invention, and the impact of these on society.

Table 2: Links between junior cycle science and literacy and numeracy

Literacy and numeracy
The development of literacy and numeracy skills is a core element of science learning. The construction of an argument and its critical evaluation, and the interrogation of data are central to science and to the learning of science. Learning science will provide students with rich and varied literacy development experiences through reading, writing, speaking and listening. They will encounter a broad range of scientific texts, including written, visual and digital texts, learning to utilise them effectively in their study of science. They will develop their ▪ reading skills by encountering a variety of scientific texts which they will learn to read with fluency, understanding and competence using a broad range of comprehension strategies ▪ writing skills through planning, drafting and presenting scientific arguments, expressing opinions supported by evidence, and by explaining and describing scientific phenomena and relationships ▪ speaking and listening skills as they engage effectively in a range of purposeful discussions on their own investigations and on scientific texts, topics and issues, seeking others' perspectives and expressing their own views clearly. In further developing their literacy, students will engage in communicating scientific information effectively and accurately in a variety of ways fit for purpose and audience, using relevant scientific terminology.

In their general literacy progression, students will deepen their understanding that most texts are written with a particular point of view. They will learn to recognise bias and to identify ways in which readers, viewers, or listeners are influenced, and appreciate the importance of reliable and valid evidence in the support of argument.

Learning science also provides students with rich and varied numeracy development experiences through thinking and communicating quantitatively; making sense of data, developing spatial awareness; understanding patterns and relationships; and recognising situations where mathematical reasoning can be applied to represent real-life situations mathematically, and to solve problems. They will be provided with opportunities to develop their

- ability to think and communicate quantitatively through investigating in science as they collect, represent, describe, and interpret numerical data, and learn how to deal with variations in the data
- ability to make sense of data as they examine primary and/or secondary data to draw justified conclusions
- spatial awareness through engagement with measurement and developing models to represent physical phenomena and relationships
- understanding of patterns and relationships as they explore various problem situations and identify the relevant factors in the problem and their relationships, in order to formulate hypotheses.

As students engage with science, they will come to appreciate the fun of exploring mathematical problems in the context of a scientific idea and the satisfaction of arriving at a solution. Through this they gain an understanding of data analysis as a tool for learning about the world.

Table 3: Links between junior cycle science and other key skills

Other key skills		
Key skill	**Key skill element**	**Student learning activity**
Being creative	Exploring options and alternatives	As students engage in scientific inquiry, they generate and seek to answer their own questions. They try out different approaches when working on a task and evaluate what works best.
Communicating	Using numbers and data	Students will interpret, compare, and present information and data using a variety of charts/diagrams fit for purpose and audience, using relevant scientific terminology.
Managing information and thinking	Being curious	As students research socio-scientific issues they will ask questions to probe the problem more deeply and to challenge how they think about the issue.
Managing myself	Making considered decisions	Students enjoy a wide range of collaborative discussions, providing them with opportunities to listen to different perspectives when considering their options.
Staying well	Being safe	Students will engage frequently with planning and conducting practical activities: they will learn to recognise when their personal safely is threatened and respond appropriately.
Working with others	Contributing to making the world a better place	Students enjoy frequent opportunities to discuss and debate issues relating to sustainability. They will learn to think critically about the world and its problems and propose solutions.

Links between junior cycle science and scientific literacy

One of the aims of this specification is to help students to develop their scientific literacy. The *PISA 2015 Draft Science Framework* includes the following definition for scientific literacy:

> *Scientific literacy is the ability to engage with science-related issues, and with the ideas of science, as a reflective citizen.*

A scientifically literate person is described as someone who is willing to engage in reasoned discourse about science and technology. This requires them to be able to explain phenomena scientifically, evaluate and design scientific inquiry, and interpret data and evidence scientifically.

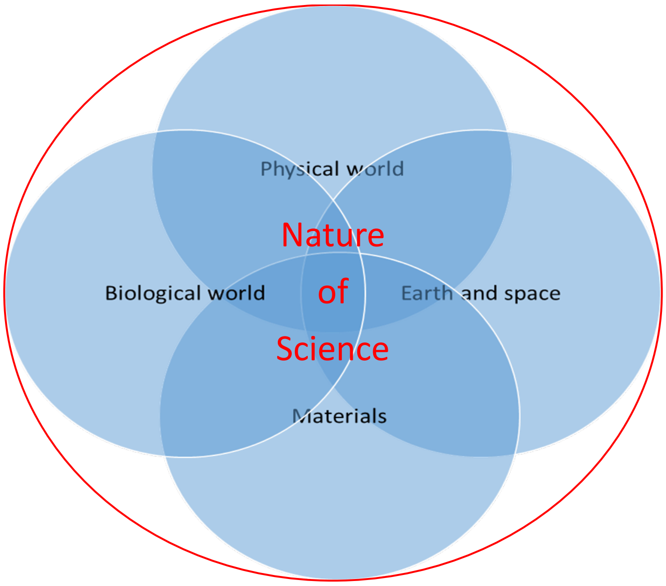
Table 4: Links to scientific literacy

Scientific literacy	
Explain phenomena scientifically	Students will recall and apply appropriate scientific knowledge to identify, use and generate explanatory models.
Understand scientific inquiry	Students will distinguish questions that are possible to investigate scientifically; propose a way of exploring a given question scientifically; pose testable hypotheses and evaluate and compare strategies for investigating hypotheses.
Interpret scientific evidence	Students will engage critically in a balanced review of scientific texts. Through this they will learn to identify the assumptions, evidence and reasoning in science-related texts, and distinguish between arguments which are based on scientific evidence and theory, and those which are not.

Overview: Course

The specification for junior cycle science focuses on the development of students' knowledge of and about science through the unifying strand, **Nature of science,** and the four contextual strands: **Physical world, Materials, Biological world,** and **Earth and space.** It has been designed for a minimum of 200 hours of engagement across the three years of junior cycle.

Figure 1: The strands of the specification for junior cycle science



Nature of science

This is the unifying strand; it permeates all the strands of the specification. The elements of this strand place a focus on how science works; carrying out investigations; communicating in science; and developing an appreciation of the role and contribution of science and scientists to society. There is a strong focus on scientific inquiry. There is no specific content linked to the Nature of science strand itself, and its learning outcomes underpin the activities and content in the contextual strands. The learning outcomes are pursued through the contextual strands as students develop their content knowledge of science through scientific inquiry. In doing so, students construct a coherent body of facts, learn how and where to access knowledge, and develop scientific habits of mind and reasoning skills to build a foundation for understanding the events and phenomena they encounter in everyday life. This makes the science classroom a dynamic and interactive space, in which students are active participants in their development. They can engage not only in experimental activities and discussion within the classroom, but also in researching and evaluating information to look beyond claims and opinions to analyse the evidence which supports them.

Materials

This strand involves the study of matter and the changes it undergoes. As students study this strand they will develop understandings of the composition and properties of matter, the changes it undergoes, and the energy involved. They learn to interpret their observations by considering the properties and behaviour of atoms, molecules, and ions. They learn to communicate their understandings using representations, and the symbols and conventions of chemistry. Our way of life depends on a wide range of materials produced from natural resources. This strand considers how measurement of the properties of materials can inform the choice of a material for a particular purpose. Students learn that in selecting a material for a particular purpose we should not only assess its fitness for purpose, but also the total effects of using the materials that make up the product over its complete lifecycle. Using this, they are better able to understand science-related challenges, such as environmental sustainability and the development of new materials, and sources of energy.

Earth and space

This strand provides an ideal setting for developing generalising principles and crosscutting concepts. To develop a sense of the structure of the Universe and some organising principles of astronomy, students explore relationships between many kinds of astron omical objects and evidence for the history of the universe. Students use data to discern patterns in the motion of the Sun, Moon, and stars and develop models to explain and predict phenomena such as day and night, seasons, and lunar phases. The cycling of matter, with carbon and water cycles as well-known examples, provides a rich setting for students to develop an understanding of many physical and chemical processes including energy conservation and energy resources, weather and climate, and the idea of cycling itself. They will come to appreciate the impact of human activity on Earth and explore the role and implications of human space exploration.

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Physical world

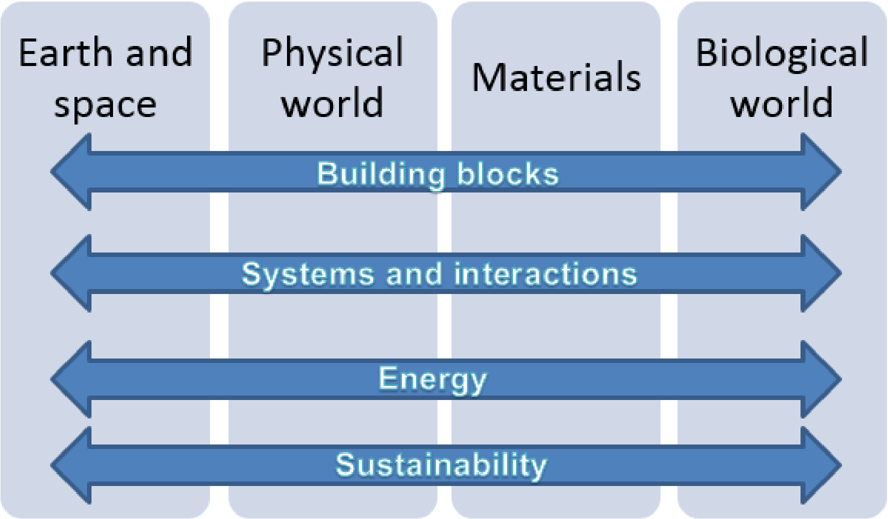
This involves the exploration of physical observables, often in relation to motion, energy, and electricity. Students gain an understanding of fundamental concepts such as length, time, mass and temperature through appropriate experiments. This allows them to develop simultaneously a sense of scaling and proportional reasoning, to recognise the need for common units, and to select and use appropriate measuring equipment. Exploring concepts such as area, density, current, and energy helps students develop the ability to identify and measure a range of physical observables, and through experimenting, to investigate patterns and relationships between them. Students also design and build simple electronic circuits. Students develop an understanding of the concept of energy and how it is transformed from one form to another without loss. They also research sustainability issues that arise from modern physics and technologies, and our generation and consumption of electricity.

Biological world

This strands leads students to an understanding of living things and how they interact with each other and the environment. In this strand students are introduced to the cell as the basic unit of life, and how characteristics are inherited from one generation to the next. Students develop an understanding of the diversity of life, life processes and how life has evolved. Students will explore body systems and how they interact, and learn about human health. They will investigate living things and their interdependence and interactions with ecosystems. They will learn about issues of social importance, such as the impact of humans on the natural world.

While the learning outcomes associated with each strand are set out separately here, this should not be taken to imply that the strands are to be studied in isolation. To give further emphasis to the integrated nature of learning science (Figure 1), the outcomes for each of the contextual strands are grouped by reference to four **elements:** Building blocks, Systems and interactions, Energy, and Sustainability (Figure 2).

Figure 2: The elements of the contextual strands showing the integrated nature of the specification



Within each strand, content areas and skills have been selected that all students should engage with while maintaining a balance between depth and breadth.

Table 5: The elements of the contextual strands

Element	
Building blocks	Focuses on the essential scientific ideas that underpin each strand.
Systems and interactions	Examines how a collection of living and/or non-living things and processes interact to perform some function/s: there is a focus on the input, outputs, and relationships among system components.
Energy	A unifying concept that allows students to develop their across the strands: it is an obvious integrating element as all phenomena we observe on earth and in space involve the transformation and variation of energy.
Sustainability	Focuses on the concept of meeting the needs of the present without compromising the ability of future generations to meet their needs.

Teaching and learning

Different students learn best in different ways. This specification allows teachers to employ a variety of approaches depending on the targeted learning outcomes, the needs of their students, and their personal preferences. The inquiry-based design supports the use of a wide range of teaching, learning, and assessment approaches, and emphasises the practical experience of science for each student. The importance of the processes of science as well as knowledge and understanding of concepts is reflected throughout the learning outcomes, which describe the understanding, skills and values that students should be able to demonstrate at the end of junior cycle.

Learning through inquiry is often characterised by the amount of student self-direction and teacher guidance. It is envisaged that opportunities for student-led inquiry, with appropriate levels of scaffolding, will be provided within each year. In this way students may pursue the outcomes of the Nature of Science strand through the content and skills identified in the contextual strands. It is recognised that the skills, knowledge and understanding of the scientific concepts as set out in the learning outcomes take time to develop and often need to be carefully revisited and reinforced. Any one activity would seldom require students to develop the full range of skills. The features of quality (appendix 4) show different hierarchical levels students can attain as they develop a scientific habit of mind and scientific literacy. As students progress, opportunities for more detailed and comprehensive activities can be included when students have developed the confidence and capacity to apply scientific skills in increasingly complex learning situations.

Increasingly, arguments between scientists are subjects that extend into the public domain. This specification enables teachers to provide opportunities for students to investigate contemporary scientific arguments, supporting students to make connections between science, other subjects and everyday experiences. Students will engage with contemporary issues in science that affect everyday life. They will learn to interrogate and interpret data—a skill that has a value far beyond science wherever data are used as evidence to support argument. . In presenting evidence and findings, they will engage in objectively justifying and discussing conclusions.

Science also develops by people pursuing their individual interests and this specification maintains a balance between depth and breadth that affords a reasonable degree of freedom for teachers and students to make their own choices and pursue their interests. For example, aspects from the different contextual strands may be woven together and large pieces of the specification may be organised around themes or 'big ideas' that focus on areas of personal, local, national, and/or global interest. This specification offers many possible routes for an integrated science approach; the most obvious are provided by the crosscutting elements, *Energy* and *Sustainability*.

As well as varied teaching approaches, varied assessment approaches will support learning and provide information that can be used as feedback, so that teaching and learning activities can be modified to meet individual needs. Through appropriate and engaging tasks, asking higher-order questions, and giving feedback that promotes student autonomy, assessment can support learning as well as summarising achievement.

Expectations for students

'Expectations for students' is an umbrella term that links learning outcomes with annotated examples of student work in the subject or short course specification. When teachers, students or parents looking at the online specification scroll through the learning outcomes, a link will sometimes be available to examples of work associated with a specific learning outcome or with a group of learning outcomes. The examples of student work will have been selected to illustrate expectations and will have been annotated by teachers. The examples will include work that is

- in line with expectations
- ahead of expectations
- has yet to meet expectations.

The purpose of the examples of student work is to show the extent to which the learning outcomes are being realised in actual cases. Annotated examples of student work developed by teachers are included in Appendix 1.

Learning outcomes

Learning outcomes are statements that describe the understanding, skills and values students should be able to demonstrate after a period of learning. Junior cycle science is offered at a common level. The examples of student work linked to learning outcomes will offer commentary and insights that support differentiation. The learning outcomes set out in the following tables apply to all students. As set out here they represent outcomes for students at the end of their three years of study. The specification stresses that the learning outcomes are for three years and therefore the learning outcomes focused on at a point in time will not have been ‘completed’ but will continue to support the students’ learning of science up to the end of junior cycle.

To support the exploration of the learning outcomes by teachers, parents, and students a glossary of the action verbs used in the specification is included in Appendix 2. Furthermore, Appendix 3 includes some sample assessment items that illustrate the kinds of written tasks that students should be able to complete having followed the course.

The outcomes are numbered within each strand. The numbering is intended to support teacher planning in the first instance and does not imply any hierarchy of importance across the outcomes themselves, also does not suggest an order to which the learning outcomes should be developed in class.

Elements	Strand one: The nature of science
	Learning outcomes *Students should be able to*
Understanding about science	1. appreciate how scientists work and how scientific ideas are modified over time * 2. recognise questions that are appropriate for scientific investigation, pose testable hypotheses, and evaluate and compare strategies for investigating hypotheses
Investigating in science	3. design, plan and conduct investigations; explain how reliability, accuracy, precision, fairness, safety, ethics, and selection of suitable equipment have been considered* 4. produce data (qualitatively/quantitatively), critically analyse data to identify patterns and relationships, identify anomalous observations, draw and justify conclusions * 5. review and reflect on the skills and thinking used in carrying out their scientific investigations and apply their learning and skills to solving problems in unfamiliar contexts
Communicating in science	6. conduct research relevant to a scientific issue, evaluate different sources of information, understanding that a source may lack detail or show bias* 7. organise and communicate their research and investigative findings in a variety of ways fit for purpose and audience, using relevant scientific terminology and representations * 8. evaluate media-based arguments concerning science and technology*
Science in society	9. research and present information on the contribution that scientists make to scientific discovery and invention, and its impact on society* 10. appreciate the role of science in society, and its personal, social and global importance.*

*See Appendix 1 for samples of student work.

Elements	Strand two: Earth and space
	Learning outcomes *Students should be able to*
Building blocks	1. describe the relationships between various celestial objects including moons, asteroids, comets, planets, stars, solar systems, galaxies and space 2. explore a scientific model to illustrate the origin of the universe 3. interpret data to compare the Earth with other planets and moons in the solar system, with respect to properties including mass, gravity, size, and composition
Systems and interactions	4. develop and use a model of the Earth-sun-moon system to describe predictable phenomena observable on Earth, including seasons, lunar phases, and eclipses of the sun and moon 5. describe the cycling of matter, including that of carbon compounds and water, associating it with biological and atmospheric phenomena*
Energy	6. research different energy sources; formulate and communicate an informed view of ways that current and future energy needs on Earth can be met
Sustainability	7. illustrate how earth processes and human factors influence the Earth's climate, evaluate effects of climate change and initiatives that attempt to address those effects 8. examine some of the current hazards and benefits of space exploration and discuss the future role and implications of space exploration in society.

*See Appendix 1 for samples of student work.

Elements	Strand three: Materials
	Learning outcomes *Students should be able to*
Building blocks	1. investigate whether mass is unchanged when chemical and physical changes take place 2. develop and use models to describe the atomic theory of matter; demonstrate how they provide a simple way to account for the conservation of mass, changes of state, physical change, chemical change, mixtures, and their separation 3. describe and model the structure of the atom in terms of the nucleus, protons, neutrons and electrons; comparing mass and charge of protons neutrons and electrons 4. classify substances as elements, compounds, mixtures, metals, non-metals, solids, liquids, gases and solutions
Systems and interactions	5. use the Periodic Table to predict the ratio of atoms in compounds of two elements 6. develop and use models to describe the atomic theory of matter; demonstrate how they provide a simple way to account for the conservation of mass, changes of state, physical change, chemical change, mixtures, and their separation 7. investigate the properties of different materials including solubilities, conductivity, melting points and boiling points 8. investigate the effect of a number of variables on the rate of chemical reactions including the production of common gases and biochemical reactions 9. investigate reactions between acids and bases; use indicators and pH scale

Energy	10. consider chemical reactions in terms of energy, using the terms exothermic, endothermic and activation energy, and use simple energy profile diagrams to illustrate energy changes
Sustainability	11. evaluate how humans contribute to sustainability through the extraction, use, disposal, and recycling of materials.*

*See Appendix 1 for samples of student work.

Elements	Strand four: Physical world
	Learning outcomes *Students should be able to*
Building blocks	1. select and use appropriate measuring instruments* 2. identify and measure/calculate length, mass, time, temperature, area, volume, density, speed, acceleration, force, potential difference, current, resistance, electrical power *
Systems and interactions	3. investigate patterns and relationships between physical observables * 4. research and discuss a technological application of physics in terms of scientific, societal and environmental impact * 5. design and build simple electronic circuits
Energy	6. explain energy conservation and analyse natural processes in terms of energy changes and dissipation * 7. design, build, and test a device that transforms energy from one form to another in order to perform a function; describe the energy changes and ways of improving efficiency
Sustainability	8. research and discuss the ethical and sustainability issues that arise from our generation and consumption of electricity.*

*See Appendix 1 for samples of student work.

Elements	Strand five: Biological world
	Learning outcomes *Students should be able to*
Building blocks	1. investigate the structures of animal and plant cells and relate them to their functions 2. describe asexual and sexual reproduction; explore patterns in the inheritance and variation of genetically controlled characteristics 3. outline evolution by natural selection and how it explains the diversity of living things
Systems and interactions	4. describe the structure, function, and interactions of the organs of the human digestive, circulatory, and respiratory systems 5. conduct a habitat study; research and investigate the adaptation, competition and interdependence of organisms within specific habitats and communities 6. evaluate how human health is affected by: inherited factors and environmental factors including nutrition; lifestyle choices; examine the role of micro-organisms in human health
Energy	7. describe respiration and photosynthesis as both chemical and biological processes; investigate factors that affect respiration and photosynthesis*
Sustainability	8. explain human sexual reproduction; discuss medical, ethical, and societal issues 9. evaluate how humans can successfully conserve ecological biodiversity and contribute to global food production; appreciate the benefits that people obtain from ecosystems.

*See Appendix 1 for samples of student work.

Assessment

Assessment in junior cycle science

Assessment in education involves gathering, interpreting and using information about the processes and outcomes of learning. It takes different forms and can be used in a variety of ways, such as to test and certify achievement, to determine appropriate routes for learners to take through a differentiated curriculum, or to identify specific areas of difficulty or strength for a given learner. While different techniques may be employed for formative, diagnostic and certification purposes, assessment of any kind can improve learning by exerting a positive influence on the curriculum at all levels. To do this it must reflect the full range of curriculum goals.

Assessment in junior cycle science will optimise the opportunity for students to become reflective and active participants in their learning and for teachers to support this. This rests upon the provision for learners of opportunities to set clear goals and targets in their learning and upon the quality of the focused feedback they get in support of their learning. Providing focused feedback on their learning to students is a critical component of high-quality assessment and a key factor in building students' capacity to manage their own learning and their motivation to stick with a complex task or problem. Assessment is most effective when it moves beyond marks and grades to provide detailed feedback that focuses not just on how the student has done in the past but on the next steps for further learning.

Essentially, the purpose of assessment at this stage of education is to support learning. To support their engagement with assessment, teachers and schools will have access to an Assessment and Moderation Toolkit. Along with the guide to school-focused moderation, the toolkit will include learning, teaching and assessment support material, including:

- ongoing assessment
- planning for and designing assessment
- assessment tasks for classroom use
- judging student work – looking at expectations for students and features of quality
- reporting to parents
- thinking about assessment: ideas, research and reflections
- a glossary of assessment and moderation terms.

The contents of the toolkit will be an essential element of quality assurance, and it will include the range of assessment supports, advice, guidelines and exemplification that will enable schools and teachers to engage with the new assessment system in an informed way, with confidence and clarity.

Appendix 1

Annotated examples of student work

These examples of student work were generated in response to the following tasks as part of ongoing teaching and learning activities. They were devised by teachers but are not intended to generate work that would be submitted for assessment for certification:

1. Research task: My science career
2. Interpreting scientific information: Climate change and CO_2
3. Research task: Elements
4. Practical activity: How quickly does a mass bob up and down on a spring?

The teachers also generated the features of quality which accompany the tasks, which were shared with the students from the beginning of the task. The annotations are a commentary on the strengths and limitations of the piece of work. They are not intended to be examples of formative feedback to be given to students.

1. **Research task:** My science career

Strand	Nature of science
Element	Understanding about science, Science in society
Learning outcomes	Nature of science: 1. Students should be able to appreciate how scientists work and how scientific ideas are modified over time. 9. Students should be able to research and present information on the contribution that scientists make to scientific discovery and invention, and the impact of these on society.
Task	Students were asked to reflect on all that they had learned in science and identify a science career they would be interested in. They were asked to research this science career and to identify the contributions of scientists in this chosen field to solving contemporary problems. Students were asked to focus on an inspirational scientist in this chosen field and to provide specific information on this scientist's work.
Year	First year students generated the following samples of work.
Time allowed	One class for discussion/preparation. Homework completed over two evenings.
Conditions	Open access to necessary resources.
Student response format	Written in the format of student's choice.

Material used to support the task:

My science career

Description of my chosen career:

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Science knowledge I use:

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Scientists in my area have solved these problems:

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One inspiring scientist in the field and the ways they worked with others to solve an important problem:

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Student response: Sample 1a

My science career

Description of my chosen career:

My Career is A Park Ranger entrusted with protecting and preserving parklands - National State and Local Parks. Requirements needed to be a Park Ranger are Loving Nature, Outstanding Communication and ability to Stay Calm in an emergancy, etc.

Science knowledge I use:

The Subjects to be a park Ranger you need are Biology, Computer science, algebra, geometry, English is needed and enviromental Science. And High points from leaving cert.

Scientist in my area have solved these problems:

The problems in area are Solve by Park Range example - Forest Fire, Transport injured animals to a Clinic, Enforce Sederal Laws and Park Regulations.

One inspiring scientist in the field and the ways they worked with other to solve an important problem:

Clinics, Fire Fighters, and Guards help solve important problems in a emergancy ect.

Uses appropriate language to describe his/her chosen career.

Some knowledge is used for the chosen career but it is not communicated in a clear and scientific manner.

Links scientist's work to everyday life,but has not described the work of scientists in solving problems associated with the career.

Overall judgement	Ahead of expectations	In line with expectations	Has yet to meet expectations
			√

Teacher commentary(supporting the judgement made)

Shows some understanding of the career chosen. Does not describe the career using appropriate scientific language and does not describe how scientists have solved problems in this area. Overall, is not in line with the expectations described in the criteria but will improve with guidance on how to research a scientific career scientifically.

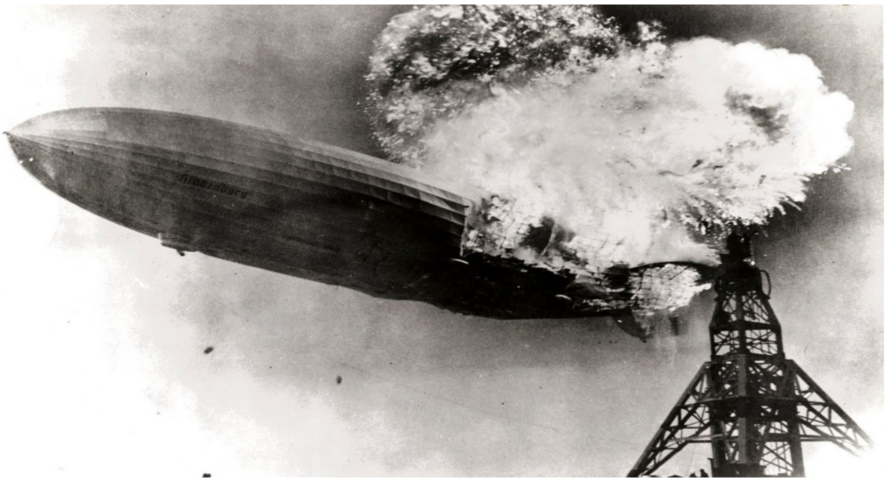
Student response: Sample 1b

My chosen career is Aviation

Description of my career:

Aviation is the science of flying aircraft. There are many different fields of aviation, there are heavier than air flight (planes)and lighter than air flight (air ships) and air traffic control. There is also aerospace which is to do with space shuttles and space travel. When you are an aviation expert you need to be very aware of safety. There have been many air crashes in aviation history but it is still statistically the safest way to travel.

Uses appropriate language to describe his/her chosen career.



Above is the Hindenburg disaster in 1937 which marked the end of airship travel.

Science knowledge I use:

An aviation expert uses many different fields of science. Key knowledge to know would be physics maths and engineering. Different fields in aviation require different areas of expertise. You would need to have a good understanding of force and motion, how the weather changes, how to calculate fuel consumption and come up with ways to reduce energy consumption, as well as being able to design models to test aircraft designs to see if they have improved for original designs.

The science knowledge used for the chosen career is appropriate and clear.

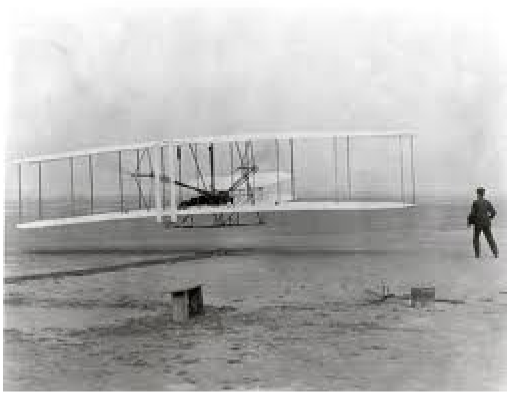
Scientists in my area have solved these problems:

Lighter than air flight

The first lighter than air flight was in 1783. The Montgolfire brothers flew the worlds first untethered hot air balloon flight but it was as short flight because as they soon relised that a balloon could only fly with the wind and was not practical unless it was a calm day. Riged airships were the first aircraft to transport corgo and people over great distances. The most well know airship company was the Zeppelin company in Germany.

Heavier than air flight

In 1799, Sir George Cayley came up with the concept of the modern airplane. There is a debate on who was the first to make and fly the first heavier than air plane. The widley accepted first heavier than air flight was in 1903 and was flew by the Wright brothers. The Wright brothers had the idea of puting an engine on a glider like plane and in world war 1 both sides used the wright brothers design for millitary planes but they did make improvements to the design for example they put the engine and the propeller at the front of the plane insted of the back like the Wright brothers had it.



The first Wright brothers flight.

Inspiring scientist in the field and the way they worked with others to solve an important problem:

David Warren was an Australian air crash investegator. When he was working on a case he found it hard to find out what happend in the final minutes of the flight. He came up with the concept of a recorder that would record all the things the pilots said and did. He than got permission to make the recorder and to this day the flight data recorder or Black Box has been able to help investagaters to find out how a crash happened

Has described the work of scientists in solving problems associated with the career.

Overall judgement	Ahead of expectations	In line with expectations	Has yet to meet expectations
		√	

Teacher commentary(supporting the judgement made)
Shows a clear understanding of the career chosen. Describes the career using appropriate language. Describes how scientists have solved problems in this area, but does not describe how scientists have worked together to solve problems. Overall, is in line with the expectations.

2. Interpreting scientific information: Climate change and CO_2

Strands	The nature of science, Earth & space, Physical world, Biological world
Element	Communicating in science, Science in society and Building blocks
Learning outcomes	Nature of science: 4. Students should be able to produce data (qualitatively/quantitatively), critically analyse data to identify patterns and relationships, identify anomalous observations, draw and justify conclusions. 6. Students should be able to conduct research relevant to a scientific issue, evaluate different sources of information, understanding that a source may lack detail or show bias. 8. Students should be able to evaluate media-based arguments concerning science and technology. 10. Students should be able to appreciate the role of science in society, and its personal, social and global importance. Earth & space: 5. Students should be able to describe the cycling of matter, such as that of carbon compounds and water, associating it with biological and atmospheric phenomena. Materials: 10. Students should be able to evaluate how humans contribute to sustainability through the extraction, use and disposal of materials. Physical world: 3. Students should be able to investigate patterns and relationships between physical observables. 4. Students should be able to research and discuss an aspect of modern physics/technologies in terms of scientific, societal and environmental impact. 8. Students should be able to discuss the ethical and sustainability issues that arise from our generation and consumption of electricity. Biological world:

	7. Students should be able to describe respiration and photosynthesis as both chemical and biological processes, and to investigate factors that affect respiration and photosynthesis.
Task	Students are given an excerpt of a science or technology related article. They must use their science knowledge to interpret the information that is provided, and to assess the validity of any claims based on the evidence.
Year	Second year students generated the following samples of work.
Time allowed	Four classes for discussion/preparation and review of relevant materials. Homework completed over two evenings.
Conditions	Open access to necessary resources, online research.

Material used to support the task:

Carbon Dioxide in the Atmosphere and Climate Change

Read the following two sources related to climate science. Answer the questions that follow.

Source 1

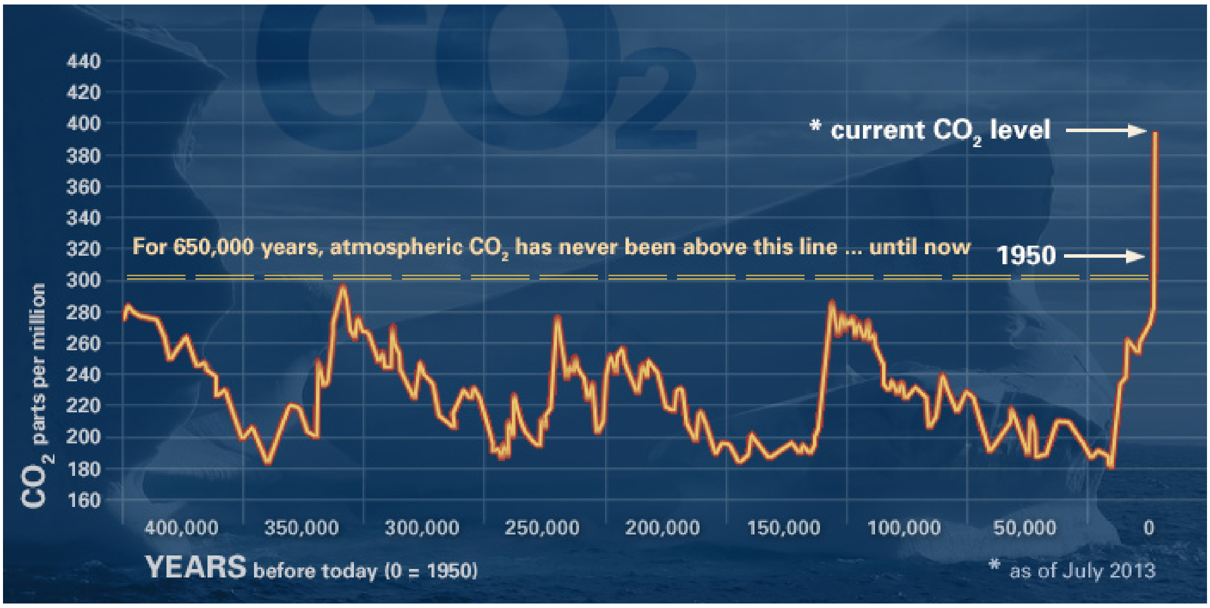
Climate change: How do we know?

The Earth's climate has changed throughout history. Just in the last 650,000 years there have been seven cycles of glacial advance and retreat, with the abrupt end of the last ice age about 7,000 years ago marking the beginning of the modern climate era — and of human civilization. Most of these climate changes are attributed to very small variations in Earth's orbit that change the amount of solar energy our planet receives.

The current warming trend is of particular significance because most of it is very likely human-induced and proceeding at a rate that is unprecedented in the past 1,300 years.

Earth-orbiting satellites and other technological advances have enabled scientists to see the big picture, collecting many different types of information about our planet and its climate on a global scale. Studying these climate data collected over many years reveal the signals of a changing climate.

Ice cores drawn from Greenland, Antarctica, and tropical mountain glaciers show that the Earth's climate responds to changes in solar output, in the Earth's orbit, and in greenhouse gas levels. They also show that in the past, large changes in climate have happened very quickly, geologically-speaking: in tens of years, not in millions or even thousands.



All three major global surface temperature reconstructions show that Earth has warmed since 1880. Most of this warming has occurred since the 1970s, with the 20 warmest years having occurred since 1981 and with all 10 of the warmest years occurring in the past 12 years. Even though the 2000s witnessed a solar output decline resulting in an unusually deep solar minimum in 2007-2009, surface temperatures continue to increase.

Source: http://climate.nasa.gov/evidence

Source 2

No Need to Panic About Global Warming

There's no compelling scientific argument for drastic action to 'decarbonize' the world's economy.

Opinion - Wall Street Journal, January 27, 2012

Although the number of publicly dissenting scientists is growing, many young scientists furtively say that while they also have serious doubts about the global-warming message, they are afraid to speak up for fear of not being promoted—or worse. They have good reason to worry. In 2003, Dr Chris de Freitas, the editor of the journal Climate Research, dared to publish a peer-reviewed article with the politically incorrect (but factually correct) conclusion that the recent warming is not unusual in the context of climate changes over the past thousand years. The international warming establishment quickly mounted a determined campaign to have Dr de Freitas removed from his editorial job and fired from his university position. Fortunately, Dr de Freitas was able to keep his university job.

This is not the way science is supposed to work, but we have seen it before—for example, in the frightening period when Trofim Lysenko hijacked biology in the Soviet Union. Soviet biologists who revealed that they believed in genes, which Lysenko maintained were a bourgeois fiction, were fired from their jobs. Many were sent to the gulag and some were condemned to death.

Why is there so much passion about global warming, and why has the issue become so vexing that the American Physical Society, from which Dr Giaever resigned a few months ago, refused the seemingly reasonable request by many of its members to remove the word "incontrovertible" from its description of a scientific issue?

Alarmism over climate is of great benefit to many, providing government funding for academic research and a reason for government bureaucracies to grow. Alarmism also offers an excuse for governments to raise taxes, taxpayer-funded subsidies for businesses that understand how to work the political system, and a lure for big donations to charitable foundations promising to save the planet. Lysenko and his team lived very well, and they fiercely defended their dogma and the privileges it brought them.

Speaking for many scientists and engineers who have looked carefully and independently at the science of climate, we have a message to any candidate for public office: There is no compelling scientific argument for drastic action to "decarbonize" the world's economy. Even if one accepts the inflated climate forecasts of the IPCC, aggressive greenhouse-gas control policies are not justified economically.

<u>Questions</u>

1 Consider the two different sources of these articles – the first from a scientific organisation and the second from a financial newspaper. How do they differ in the rules they follow when publishing an article or story?

2 What evidence does each source offer to support its argument that:

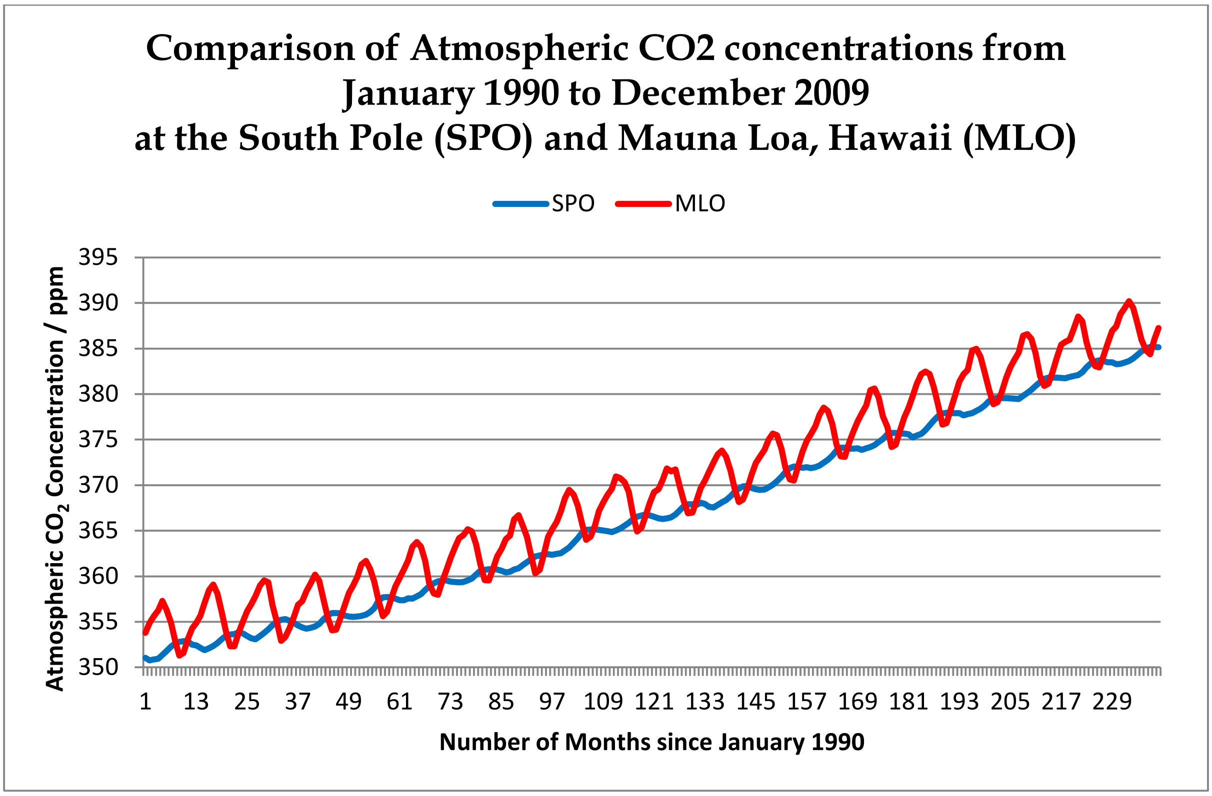
Source 1 – Global climate is changing now?

Source 2 – There is no need to reduce our production of carbon dioxide?

3 How does so much of our current energy generation produce carbon dioxide?

4 Briefly describe the process of carbon capture and storage.

Carefully examine the graph below.



These twenty years of data from both atmospheric observatories show that the CO_2 concentration in the atmosphere is rising. Within a single year, however, the level goes through a clear maximum and minimum before rising again to a higher peak level the following year. The cycle is more noticeable in Hawaii than at the South Pole.

In Hawaii (in the northern hemisphere) the levels rise throughout November/December until April/May when they begin to fall again. The pattern of this timing is the opposite at the South Pole.

5 Form a hypothesis to explain how the level of CO_2 in the atmosphere can be affected by the seasons.

6 Why might the seasonal levels change less at the South Pole than in Hawaii?

7 Why are the seasonal changes at the South Pole six months behind those in Hawaii?

8 Calculate the approximate average increase in CO_2 concentrations in *parts per million* (ppm) per year.

Student response: Sample 2a

1 Consider the two different sources of these articles – the first from a scientific organisation and the second from a financial newspaper. How do they differ in the rules they follow when publishing an article or story?

The scientific publications should draw conclusions based upon evidence, especially evidence that has been peer-reviewed. The newspaper will sometimes publish based upon reliable evidence, but also using information drawn from sources that may not be reliable. The newspaper may also be campaigning for a certain goal, according to an editor's/owner's wishes. The rules depend on the policy.

Clear description and comprehensive explanation of science knowledge used to make sense of information provided.

2 What evidence does each source offer to support its argument that:

Source 1 – Global climate is changing now?

The NASA article refers to global temperature measurements over the last 20 years, and how these seem to indicate a trend towards warmer temperatures compared to earlier in the last 130 years.

Text is interpreted, identifying the essential elements and distinguishing them from secondary elements.

Source 2 – There is no need to reduce our production of carbon dioxide?

No evidence is offered in support of the author's opinion.

Text is interpreted, identifying the essential elements and distinguishing them from secondary elements. Differentiates between the citing of evidence in Source 1 and the opinion expressed in Source 2.

3 How does so much of our current energy generation produce carbon dioxide?

The combustion of fossil fuels releases carbon dioxide gas into the atmosphere, for example, the burning of methane

$$CH_4 + 2O_2 \xrightarrow{yields} CO_2 + 2H_2O$$

Clear description and comprehensive explanation of science knowledge used to make sense of information provided.

4 Briefly describe the process of carbon capture and storage.

The process involves trapping the CO2 produced at fossil fuel burning power stations and storing it underground to prevent its release into the atmosphere.

This is evidence of further independent research having been conducted.

5 Form a hypothesis to explain how the level of CO_2 in the atmosphere can be affected by the seasons.

Throughout autumn broad-leaved trees shed their leaves and the number of hours of sunlight decreases. This causes a decrease in the amount of photosynthesis that can occur so not as much CO_2 is being absorbed from the air, and the levels rise. The new leaf growth in spring and longer hours of sunlight cause the levels to fall again temporarily.

Draws justified conclusions.

6 Why might the seasonal levels change less at the South Pole than in Hawaii?

The South Pole is very far away from the largest areas of forest on Earth, especially those in the northern hemisphere where changing seasons causes deciduous trees to lose their leaves in autumn, so the effect is not as big here.

This is a reasonable hypothesis in the absence of supporting evidence.

7 Why are the seasonal changes at the South Pole six months behind those in Hawaii?

The timing of the seasons is reversed in the southern hemisphere, and it would take a long time for the changing levels of the different gases over the other continents to mix with the air over Antarctica.

Clear description and comprehensive explanation of science knowledge used to make sense of information provided.

8 Calculate the approximate average increase in CO_2 concentrations in *parts per million* (ppm) per year.

The level measured roughly 351 ppm in January 1990 and had risen to 385 ppm by the end of 2009.

Clearly presented analysis of data.

This is a rise of 34 ppm in 20 years or an annual rate of increase of 1.7 ppm/yr.

Overall judgement	Ahead of expectations	In line with expectations	Has yet to meet expectations
	√		

Teacher commentary (supporting the judgement made)

The text is interpreted very well. The answers are concise and to the point, and the hypotheses are sound. Judging by the accurate use of terminology, there is evidence that there was thorough researching of the topic. In the answer to question 1 there is a precise distinction made between the nature of scientific publication and its rules compared to the much more lax standards required for publication in mainstream media. The other answers all show a thorough comprehension of causality.

Student response: Sample 2b

1. Consider the two different sources of these articles – the first from a scientific organisation and the second from a financial newspaper. How do they differ in the rules they follow when publishing an article or story?

   NASA should only write about things they have found out for certain, they should not say things unless they are true.

   > Identifies a scientific ideal, but has not linked the concept of truth to evidence.

   Newspapers can sometimes write things that aren't true.

2. What evidence does each source offer to support its argument that:
   Source 1 – Global climate is changing now?

   Satellites have been used to collect lots of data for a long time now and this shows the Earth is getting warmer. A lot of the warmest years have happened recently.

   > Identifies elements of relevant information.

   Source 2 – There is no need to reduce our production of carbon dioxide?

   He quotes Dr Chris de Freitas as saying that "recent warming is not unusual in the context of climate changes over the past thousand years".

   > This quote is not evidence in support of the author's position. There is not a clear understanding of the difference between an argument supported by evidence, and mere opinion.

3. How does so much of our current energy generation produce carbon dioxide?

   Burning fossil fuels gives off carbon dioxide gas, and we get a lot of energy from burning coal, oil and natural gas.

   > This is a clear and concise statement of scientific knowledge.

4. Briefly describe the process of carbon capture and storage.

Carbon capture and storage (CCS) (or carbon capture and sequestration), is the process of capturing waste carbon dioxide from large point sources, such as fossil fuel power plants, transporting it to a storage site, and depositing it where it will not enter the atmosphere, normally an underground geological formation.

A well-researched answer.

5. Form a hypothesis to explain how the level of CO2 in the atmosphere can be affected by the seasons.

   Because it is warmer in summer, people use less fuel for heating and so they produce less carbon dioxide gas, so the level falls. It rises again coming into winter as it gets colder and people use more fuel.

Draws justified conclusions.

6. Why might the seasonal levels change less at the South Pole than in Hawaii?

   There are hardly any people in Antarctica so there is not much use of fuel.

7. Why are the seasonal changes at the South Pole six months behind those in Hawaii?

   It is winter at the South Pole when it is summer in the northern hemisphere.

A clearly stated and reasonable answer.

8. Calculate the approximate average increase in CO_2 concentrations in parts per million (ppm) per year.

   The level at the first peak is about 357 ppm. 19 years later the peak is about 390 ppm. So it has gone up 33 ppm.

Overall judgement	Ahead of expectations	In line with expectations	Has yet to meet expectations
		√	

Teacher commentary (supporting the judgement made)

This work shows that the much of the textual information was correctly interpreted The answers are supported with correctly identified scientific knowledge.

The understanding of general principles is well communicated through some clear, concise and appropriate answers. There are occasional significant shortcomings: the nature and role of evidence, and the absence of a calculation to find the rate of change of CO_2 concentrations. However, a valid attempt is made to explain the seasonal variations in CO_2 based upon his/her own direct experience.

Student response: Sample 2c

1. Consider the two different sources of these articles – the first from a scientific organisation and the second from a financial newspaper. How do they differ in the rules they follow when publishing an article or story?

   The scientists know better than the reporters. The reporters only read about someone else's ideas, they don't do the research on climate themselves.

   Identifies the difference between primary and secondary research which successfully identifies a significant difference between the two.

2. What evidence does each source offer to support its argument that:

   Source 1 – Global climate is changing now?

   The scientists say that the Earth is getting warmer and there have been a lot of very warm years lately.

   The main point of the article in Source 1 is communicated.

   Source 2 – There is no need to reduce our production of carbon dioxide?

   He only says there is no need to worry about carbon dioxide. He doesn't give any reasons.

   Successfully identifies the key difference between the arguments proffered by the authors of Sources 1 and 2.

3. How does so much of our current energy generation produce carbon dioxide?

   By burning fuels.

   A succinct description of scientific knowledge.

4. Briefly describe the process of carbon capture and storage.

   Carbon capture is holding on to carbon dioxide and not letting it get into the air.

5. Form a hypothesis to explain how the level of CO2 in the atmosphere can be affected by the seasons.

The level goes down in summer when it is hot and goes up again when it gets cold.

This accurate observation, interpreted from the text, requires some mechanism for a causal relationship to be offered to constitute a hypothesis.

6. Why might the seasonal levels change less at the South Pole than in Hawaii?

   Because it is so cold.

7. Why are the seasonal changes at the South Pole six months behind those in Hawaii?

   The seasons there are the opposite of ours.

A statement of knowledge used to make sense of the information provided.

8. Calculate the approximate average increase in CO2 concentrations in parts per million (ppm) per year.

   The level goes up and down by about 10 ppm every year.

Fair observation for a single year in isolation. The trend over a longer timescale could be addressed.

Overall judgement	Ahead of expectations	In line with expectations	Has yet to meet expectations
			√

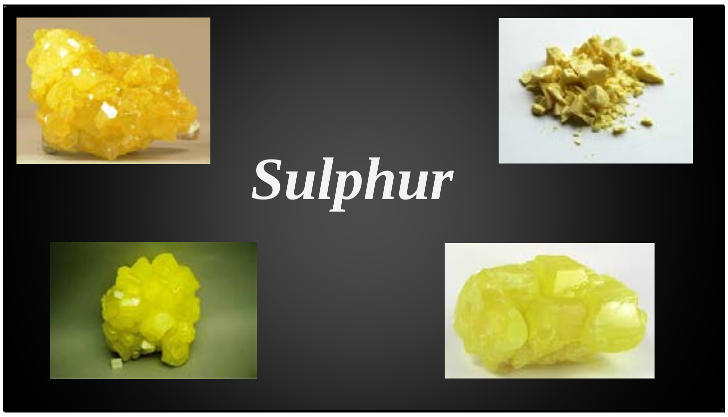
Teacher commentary (supporting the judgement made)

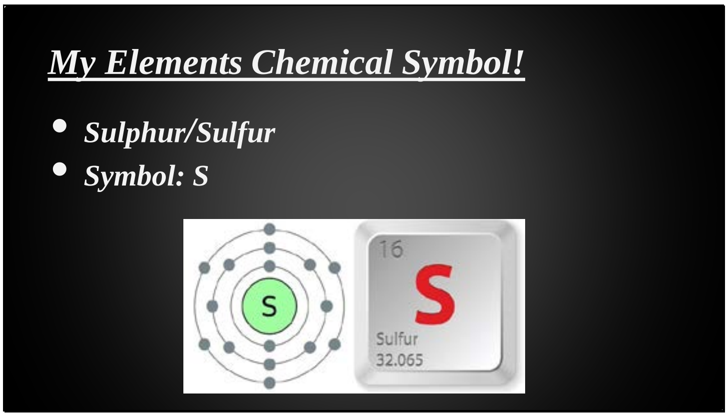
This sample of work contains some brief and accurate answers but needs to analyse the information more deeply. The work should show some evidence of the nature of causation; a couple of answers are short on detail.

3. **Research task:** Elements

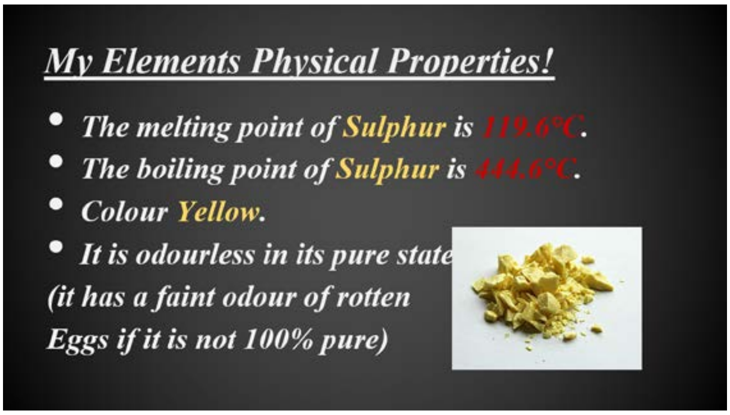
Strand	Nature of science and Materials
Element	Communication in science, Building blocks
Learning outcomes	Nature of science 7. Students should be able to organise and communicate their research and investigate findings in a variety of ways fit for purpose and audience, using relevant scientific terminology and representations. Materials: 3. Students should be able to describe and model the structure of the atom in terms of the nucleus, protons, neutrons and electrons; comparing mass and charge of protons, neutrons and electrons. 4. Students should be able to classify substances as elements, compounds, mixtures, metals, non-metals, solids, liquids, gases and solutions.
Task	Students were asked to research an element from the periodic table. They were asked to describe and model the structure of an atom of that element, and describe the physical and chemical properties, history and uses of the element. On completing the task, students were asked to present the information to the other students in the class.
Year	First year students generated the following samples of work.
Time allowed	One class for discussion/preparation. Homework completed over two evenings. One class for presentation of research.
Conditions	Open access to necessary resources.
Student response format	Written, PowerPoint presentation, poster or video clip.

Student response: Sample 3a

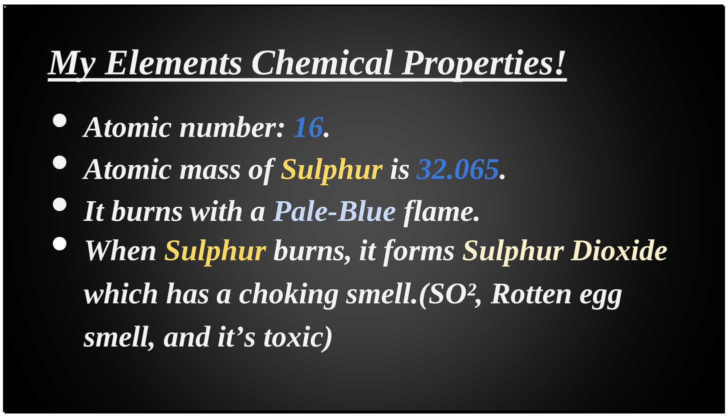




A Bohr model, while not necessary to be memorised by students, is presented showing evidence of research of the topic. Appropriate representations are used that are relevant and clear. There is no mention of the terms protons, neutrons and electrons, but this is a good starting point to find out more about the nucleus.

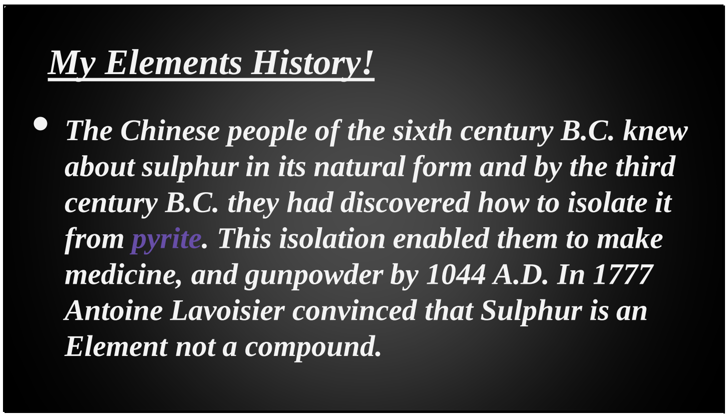


Describes some of the physical properties of sulphur using appropriate language.

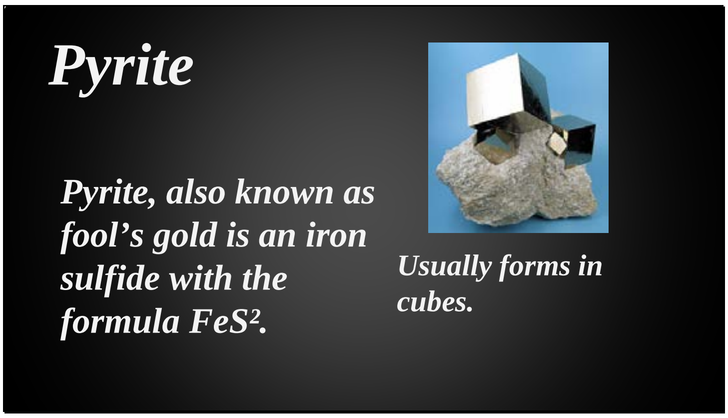


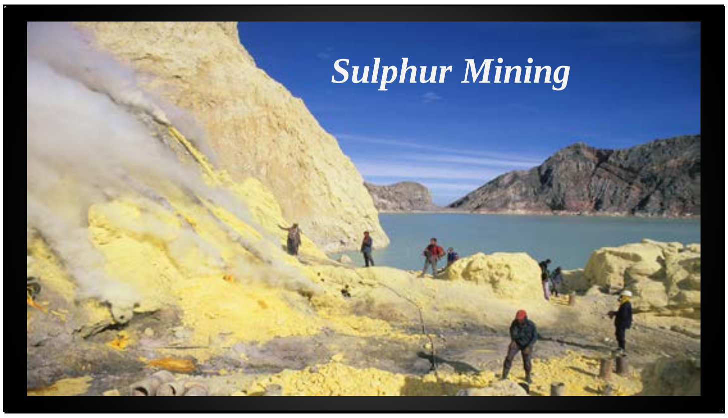
Describes some of the chemical properties of sulphur in detail.

Good representations are used to communicate research of the topic. The term 'heated' is the relevant scientific term to be used instead of 'burned'.



The element's history is described in detail.





My Elements Uses!

- *The main use of sulphur is in the preperation of SO^2 which is used in the manufacture of sulphuric acid.*
- *Sulphur is used in ointments for curing skin diseases.*

The uses of the element are clearly described.

- *Sulphur is also used to make fireworks as it is one of the ingredients of gunpowder.*

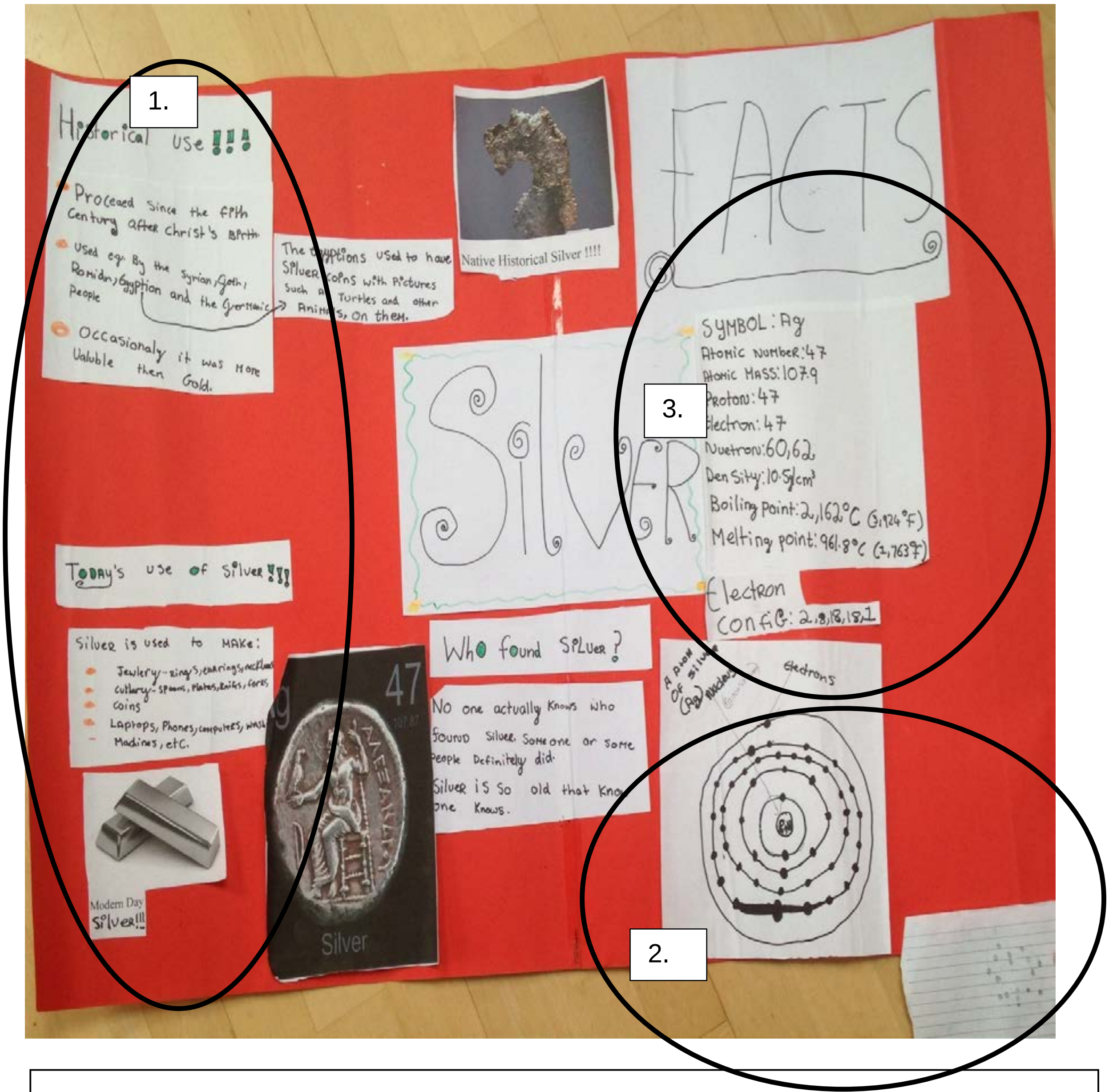
Did you know?

Lapis Lazuli owes its blue colour to a sulphur radical. S^3 Trisulphur

Overall Judgement	Ahead of expectations	In line with expectations	Has yet to meet expectations
		√	

Teacher commentary (supporting the judgement made)
Appropriate language is used to organise and communicate the research and much relevant scientific terminology and representations are used throughout the work. The chosen element is described in detail. This work could be judged to be 'in line with expectations' based on the written evidence alone. However, the student presented these slides to the class and did an excellent job that revealed a deeper understanding, overall it was judged to be at the upper end of 'in line with expectations'.

Student response: Sample 3b



1. **1.** The poster uses appropriate language to describe the element and contains information that indicates independent research was conducted. This information is described clearly.
2. **2.** The poster displays a model of the structure of an atom of silver.
3. **3.** Physical properties of the element are identified but some of the more obvious physical properties are not mentioned, such as hardness, colour, conductivity etc. There is no attempt to identify any chemical properties or to classify the named properties as physical or chemical properties.
4. **4.** The student used the poster to present the information to the rest of the students in the class. The presentation was clear and appropriate for the rest of the students in the class.

Overall judgement	Ahead of expectations	In line with expectations	Has yet to meet expectations
		√	

Teacher commentary (supporting the judgement made)

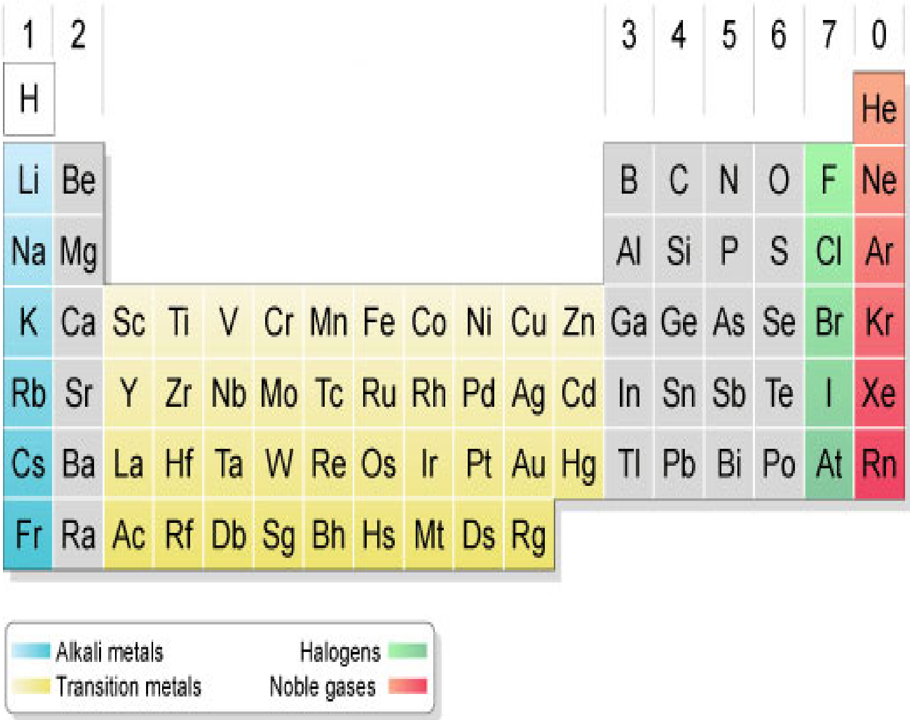
Appropriate language is used to organise and communicate the research. The element was described clearly on the poster. The features of quality of the written evidence are similar to those of sample 3a. Additional evidence from presenting the poster suggested that this student's understanding was not deeper or less deep than the poster suggested. Overall, it was judged that this work is in line with expectations.

Student response: Sample 3c

MY PROJECT ON:
ZINC

Zinc's chemical symbol. It is number 30 on the Periodic Table.

> Does not describe a model of the structure of the element zinc.



The Periodic Table has 83 elements! Some of the elements include:

- **He… Helium**
- **Zn… Zinc**
- **Cu… Copper**

ZINC PHYSICAL PROPERTIES

- **Zinc is silver in colour.**
- **It is a solid.**
- **It is a metal.**

Lists one obvious physical property of zinc but confuses a physical state and a classification of a substance as physical properties.

ZINC CHEMICAL PROPERTIES

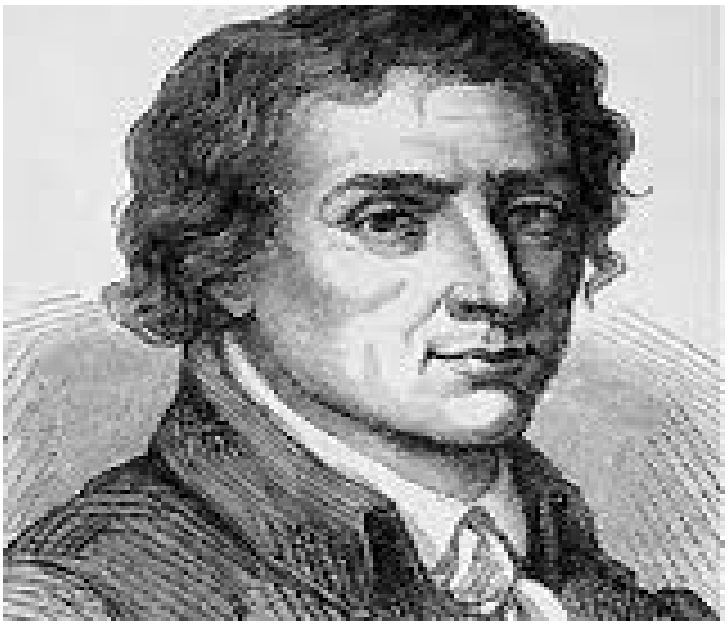
- **Zinc's boiling point is 907 Degrees Celsius.**
- **Zinc's melting point is 420 Degrees Celsius.**
- **Zinc's atomic weight is 65.409**

Reveals a lack of understanding of physical and chemical properties. Incorrectly identifies some physical properties of zinc as chemical properties.

ZINC HISTORY

- **Zinc was discovered by Andreas Sigismund Marggraf.**
- **He discovered it in 1746 in Germany.**
- **He discovered zinc in 1746 by heating calamine and carbon.**

Clearly describes the history of zinc. The third point lacks the detail to explain that the zinc was extracted from the calamine.
It is possible there is a misunderstanding of how to classify a substance as an element, i.e. does this point suggest that zinc is produced from a chemical reaction.



ZINC'S USES

- Zinc is used in roofing materials.
- Zinc is widely used in the manufacture of very many products such as paints, rubber, cosmetics, pharmaceuticals, plastics, inks, soaps, batteries, electrical equipment and fluorescent lights.
- Zinc is also used to make guns

Uses of zinc described using appropriate language.

Overall judgement	Ahead of expectations	In line with expectations	Has yet to meet expectations
		√	

Teacher commentary (supporting the judgement made)

There is evidence that independent research was conducted, and the language used is appropriate. There is evidence of a lack of understanding of physical and chemical properties and a possible misunderstanding of what constitutes an element. The oral presentation of this information to the class was not clear. For this reason, work like this would be at the lower end of being in line with expectations.

4. Practical activity: How quickly does a mass bob up and down on a spring?

Strand	Nature of science and Physical world
Element	Investigating in science, Communicating in science and Building blocks
Learning outcomes	Nature of science: 3. Students should be able to design, plan and conduct investigations; explain how reliability, accuracy, precision, fairness, safety, ethics, and the selection of suitable equipment have been considered. 4. Students should be able to produce data (qualitatively/quantitatively), critically analyse data to identify patterns and relationships, identify anomalous observations, draw and justify conclusions. 7. Students should be able to organise and communicate their research and investigative findings in a variety of ways fit for purpose and audience, using relevant scientific terminology and representations. Physical world: 1. Students should be able to select and use appropriate measuring instruments. 2. Students should be able to identify and measure/calculate length, mass, time, temperature, area, volume, density, speed, acceleration, force, potential difference, current, resistance, electrical power. 3. Students should be able to investigate patterns and relationships between physical observables. 6. Students should be able to explain energy conservation and analyse natural processes in terms of energy changes and dissipation.
Task	Students were asked the question, 'How quickly does a mass bob up and down on a spring?'. Presented with a range of materials, they were then asked to plan and carry out an experiment to answer this question. They were also required to graphically display the relationship between a measured variable and time.

Year	Second year students generated the following samples of work.
Time allowed	One class for discussion/preparation - with emphasis on measurement and error. Two classes for data collection and completion of worksheet. Homework completed over two evenings – production of proportional graph and conclusion regarding the patterns in the data.
Conditions	Open access to necessary resources.
Student response format	Written investigation report including worksheet, graph & conclusion.

Material used to support the task:

Name: __________________________

How quickly does a mass bob up and down on a spring?

Try to imagine a rubber duck floating in a pond when someone drops a stone into the water nearby. Waves from the stone spread out and when they reach the rubber duck it gently bobs up and down till the water settles.

This kind of up and down or back and forth motion is very common in nature – a pendulum gently swinging, a diving board after someone jumps into a pool, or a ship at the quayside rising and falling on the tide are all similar examples.

In a laboratory, we can study this type of motion by analysing how quickly a mass bobs up and down when hanging from a spring.

You have been given a box containing some equipment: retort stand and clamp, selection of 5 springs of various elastic constants, a set of slotted masses/weights (100g or 1N), a stopwatch, a pan balance, a ruler/metre-stick, graph paper & calculator. Hang a mass from a spring and set it bobbing up and down. Watch the way it behaves. Now examine all of the items in the box and think how you might design an experiment to see how quickly a mass bobs up and down on a spring.

List the variables you think might affect the mass as it moves.

Decide which variables you are going to measure. Explain how you think these variables might govern the way the mass moves.

Put your experiment design into action. Assemble the equipment as you see fit and collect your data. Think carefully about how you will analyse and present your data. The following headings can be used to guide you as you prepare a report of your investigation:

- Experiment title
- List of apparatus

- Diagram
- Method
- Results
- Analysis and conclusion
- Sources of error
- Suggested improvements to design.

Student response: Sample 4a

How quickly does a mass bob up and down on a spring?

List the variables you think might affect the mass as it moves.

How hard you pull down on the mass before letting it go, how long it bounces up and down for

Includes some relevant variables but no control variables are mentioned.

Decide which variables you are going to measure. Explain how you think these variables might govern the way the mass moves.

I am going to measure the distance I pull down the mass before letting go of it, then I am going to see how long it takes to stop moving.
If I pull it down further it should bounce up and down for longer.

This is a plausible hypothesis that can be investigated scientifically.

The goal is stated clearly, but it is not fully aligned with the research question.

Experiment title: *How pulling harder on a spring makes it bounce longer*

List of apparatus

A spring, a retort stand and clamp, a timer, a mass, a ruler.

Method

1. *I set up the equipment as in the diagram.*
2. *I attached the mass to the spring.*
3. *I pulled the mass down 1 cm.*
4. *I released the mass and started the timer at the same moment.*
5. *I stopped the timer when the mass stopped moving.*
6. *I wrote down the distance the mass was pulled down and the length of time it moved up and down for.*

Fairly clear description of the method.

Results

x / cm	*t / s*
1	*33*
2	*43.2*

Table of results presented clearly, but there is no graphical representation of the data.

3	*49*
4	*53*
5	*56*
6	*59*

x = distance mass was pulled down at start

t = time taken for mass to stop bobbing

Analysis & conclusion

My results show that the farther down I pull the mass attached to the spring the longer it takes to stop. This is what I predicted would happen.

A pattern is identified.

Sources of error

It was difficult sometimes to see whether the mass had fully stopped moving.

Overall judgement	Ahead of expectations	In line with expectations	Has yet to meet expectations
			√

Teacher commentary (supporting the judgement made)

This work reveals some good understanding of how to conduct a scientific investigation. However, the experiment that was planned does not set out to answer the question that was actually asked. The work lacks critical analysis of data, and there is no graphical representation of data. While the source of error was identified, there was no attempt to reduce sources of error.

Student response: Sample 4b

How quickly does a mass bob up and down on a spring?

List the variables you think might affect the mass as it moves.

How long the spring is, the metal the spring is made with, the mass hanging on the spring, how far you pull the mass down to set it bobbing

Relevant variables listed.

Decide which variables you are going to measure. Explain how you think these variables might govern the way the mass moves.

I am going to measure the time it takes for the mass to bounce up and down. I have tried hanging a few masses from the springs – one stretches all the way to the table even with only 0.2 kg on it. Two springs barely stretch even with 1 kg on it. I broke another spring by stretching it too far and it lost its shape. So I had only really one spring to work on.

This is a plausible hypothesis that can be investigated scientifically.

Goals are aligned with the research question.

I think a heavier mass will move slower up and down, so I will put different masses on the end of the spring each time and see how long it takes to go up and down once.

Experiment title: *The effect of mass on the bouncing movement of a spring*

List of apparatus

Retort stand and clamp, a spring, a timer, masses on a hook.

Method

Clear description of the method.

1. *I set up the equipment as in the diagram.*
2. *I noted the mass hanging on the spring.*
3. *I made the mass bob up and down.*
4. *When the mass was at its lowest point I started the timer and I stopped it when it finished its 5th time up and down. I wrote this time down in the table.*
5. *I found how long it took the mass to go up and down once.*

6. *I drew a graph of time (on the horizontal axis) vs mass hanging from the spring (on the vertical axis).*

Results

t / s	T / s	m / kg
6.40	1.28	0.3
7.40	1.48	0.4
8.25	1.65	0.5
9.10	1.82	0.6
9.90	1.98	0.7
10.45	2.09	0.8
11.00	2.20	0.9

t = time for 5 bounces

T = time for one bounce

m = mass hanging on spring

Graph

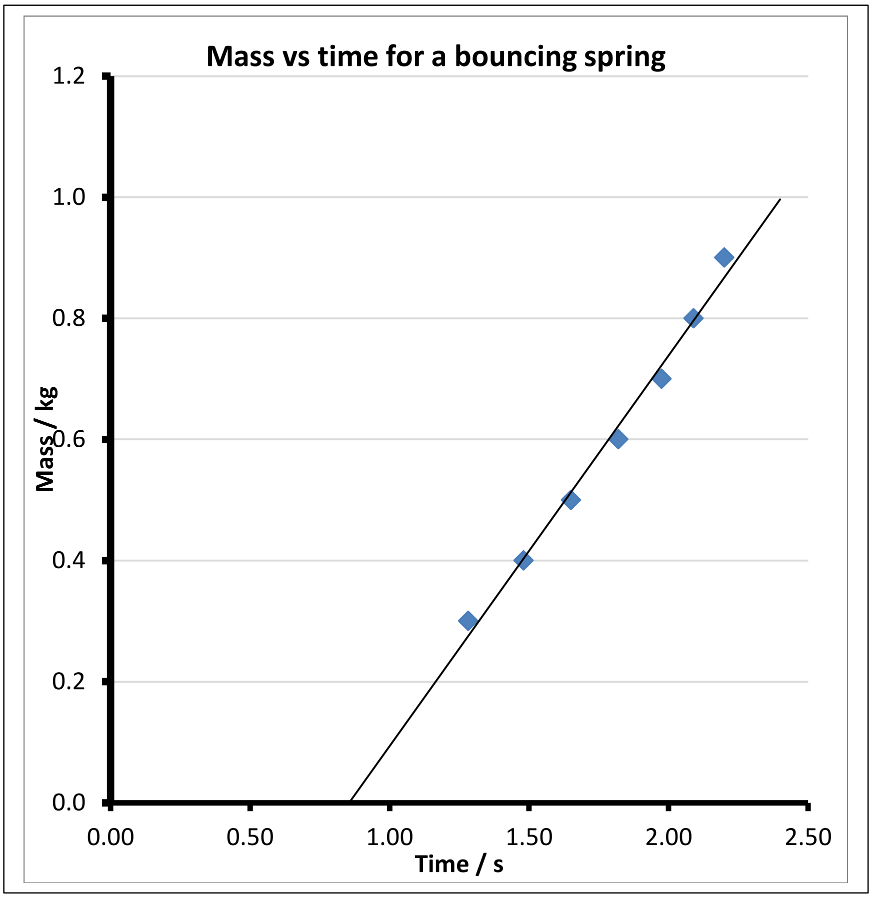


Table of results and graph clearly present results. The points fit a curve but a straight line graph is presented. Placing the variable that was changed (mass) on the x-axis may have made this more obvious. This graph suggests that the spring would bob up and down when no mass is on the spring.

Analysis & conclusion

The line of best fit drawn through the data points show that there is a clear correlation between the time it takes for the spring to move up and down once and how heavy the mass is that is attached onto the end.

An explanation is given for the relationship between mass and the periodic time.

The bigger the mass the longer the motion takes. This result agrees with my hypothesis at the start.

Sources of error

The base of the retort stand wobbled a tiny bit when I set the mass bobbing – this might cause errors. It was difficult to start the timer and stop it at exactly the right times.

These are relevant limitations and clearly identified.

Suggested improvements to design

If I had to collect the data again I would use a C-clamp from woodwork to fix the base of the retort stand to the table to stop any wobbling.

The first limitation – the wobble – is dealt with satisfactorily. No suggestions are offered for the second limitation identified above.

Overall judgement	Ahead of expectations	In line with expectations	Has yet to meet expectations
		√	

Teacher commentary (supporting the judgement made)

The hypothesis was explicitly stated at the beginning, and the result seems clearly in agreement with it. The effort made to minimise the random error in the timing of an event of short duration is not sufficiently explained.

The graph is precise in the plotting of points and the axes are correctly labelled with quantities and units, but the student missed the possibility that the point distribution hints at a curve, the linear relationship described is incorrect. A more accurate rendering of the timing issue might have made the curve more visible to the student.

Student response: Sample 4c

How quickly does a mass bob up and down on a spring?

List the variables you think might affect the mass as it moves.

The stiffness of the springs, the value of the mass hanging from the spring, the extension from the resting position and the room temperature

Relevant variables that could affect the motion are stated.

Decide which variables you are going to measure. Explain how you think these variables might govern the way the mass moves.

Uses language appropriate to this type of motion and some level of familiarity with key ideas has been attained.

I will measure the periodic time of the motion – the question asked me "How quickly. . ", so a shorter time would mean the mass is moving quicker. The room temperature will stay roughly the same, so it probably won't cause a change in the behaviour of the spring. Different springs have different stiffnesses, so I'll collect all the data using one spring first.

I think a spring attached to a heavier mass will move more slowly and have a longer periodic time , so I plan to measure the periodic time for different masses to see how the two variables are related. I will use the same extension each time I set the mass moving to stop the extension being a variable.

This is a plausible hypothesis that can be investigated scientifically.

Goals are aligned with the research question, and are stated clearly.

Good analysis of the effect of variables.

Experiment title: *The effect of mass on the bouncing movement of a spring*

List of apparatus

Retort stand and clamp, a spring, a timer, masses on a hook.

Method

1. *I set up the equipment as in the diagram.*
2. *I attached a 100 g mass to the spring.*
3. *I pulled the mass down 4 cm and released it.*

This level of detail makes the method very easy to reproduce.

4. *I let the movement settle down to a steady rhythm then when the mass was at its lowest point I started the timer.*
5. *I stopped the timer when the mass had completed 10 oscillations.*
6. *I divided this time by 10 to find the periodic time – the time for one oscillation.*
7. *I added 100 g to the spring and repeated steps 3 to 6.*
8. *I repeated the process until I had collected the periodic time for 7 different masses, 100 g to 700 g.*
9. *I drew a graph of mass (on the horizontal axis) vs periodic time (on the vertical axis).*

Results

m / kg	t / s	T / s
0	0	0
0.3	5.10	0.26
0.4	5.88	0.29
0.5	6.50	0.33
0.6	7.19	0.36
0.7	7.66	0.38
0.8	8.26	0.41
0.9	8.72	0.44
1.0	9.12	0.46

m = mass on spring / kg

t = time for ten oscillations / s

T = periodic time / s

Graph

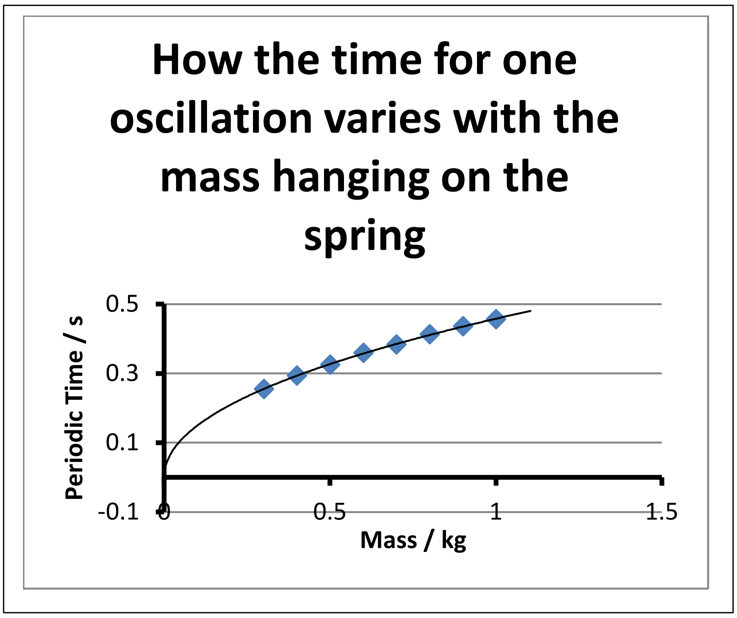


Table of results and graph clearly present results.

Analysis & conclusion

The graph clearly shows a curve representing the relationship between periodic time and the value of the mass attached to the spring.

As mass increases the periodic time also increases. The bigger the mass the greater the force needed to give it the same acceleration. That is why it slows as the mass increases.

> Analyses pattern in data, identifies consistent relationship in results.
> This analysis shows a good understanding of the relationship between force and acceleration.

Sources of error

The retort stand seemed to move a bit as the mass bobbed up and down so I put some heavy books on the base to steady it. The mass wobbled a lot each time I let it go, so I let it settle into its motion before putting on the timer.

> These are relevant limitations and are addressed them with some success.

Suggested improvements to design

I would like more time to repeat the experiment for different springs. The stiffer they are the faster they would make the mass oscillate. I would like to use less stiff springs – the slower periodic times obtained would reduce further the error in timing.

> This is a very well thought-through proposition.

Overall judgement	Ahead of expectations	In line with expectations	Has yet to meet expectations
	√		

Teacher commentary (supporting the judgement made)

The identification of variables, the understanding of cause and effect between the chosen variables and the efforts to keep other variables fixed are the hallmarks of good investigative practice. The use of specific language indicates thorough research into the problem, and reflects the level of comprehension attained. This is a very well researched, planned and executed investigation.

Appendix 2

Glossary of action verbs

Action verb	Students should be able to
Analyse	study or examine something in detail, break down something in order to bring out the essential elements or structure; identify parts and relationships, and interpret information to reach conclusions
Apply	select and use information and/or knowledge and understanding to explain a given situation or real circumstances
Appreciate	recognise the meaning of; have a practical understanding of
Calculate	obtain a numerical answer, showing the relevant stages in the working
Classify	group things based on common characteristics
Compare	give an account of the similarities and/or differences between two (or more) items or situations, referring to both/all of them throughout
Conduct	to perform an activity
Consider	describe patterns in data; use knowledge and understanding to interpret patterns; make predictions and check reliability
Demonstrate	prove or make clear by reasoning or evidence, illustrating with examples or practical application
Describe	develop a detailed picture or image of, for example, a structure or a process, using words or diagrams where appropriate; produce a plan, simulation or model
Design	to conceive, create and execute according to plan
Develop	to evolve; to make apparent or expand in detail
Discuss	offer a considered, balanced review that includes a range of arguments, factors or hypotheses: opinions or conclusions should be presented clearly and supported by appropriate evidence
Evaluate (data)	collect and examine data to make judgments and appraisals; describe how evidence supports or does not support a conclusion in an inquiry or investigation; identify the limitations of data in conclusions; make judgments about ideas, solutions or methods
Evaluate (ethical judgement)	collect and examine evidence to make judgments and appraisals; describe how evidence supports or does not support a judgement;

Action verb	Students should be able to
	identify the limitations of evidence in conclusions; make judgments about ideas, solutions or methods
Examine	consider an argument or concept in a way that uncovers the assumptions and relationships of the issue
Explain	give a detailed account including reasons or causes
Explore	observe, study, in order to establish facts
Formulate	express the relevant concept(s) or argument(s) precisely and systematically
Identify	recognise patterns, facts, or details; provide an answer from a number of possibilities; recognise and state briefly a distinguishing fact or feature
Illustrate	use examples to describe something
Interpret	use knowledge and understanding to recognise trends and draw conclusions from given information
Investigate	observe, study, or make a detailed and systematic examination, in order to establish facts and reach new conclusions
Justify	give valid reasons or evidence to support an answer or conclusion
Measure	quantify changes in systems by reading a measuring tool
Model	generate a mathematical representation (e.g., number, graph, equation, geometric figure); diagrams; physical replicas for real world or mathematical objects; properties; actions or relationships
Organise	to arrange; to systematise or methodise.
Outline	to make a summary of the significant features of a subject.
Plan	to devise or project a method or a course of action
Produce	to bring into existence by intellectual or creative ability
Research	to inquire specifically, using involved and critical investigation
Review	to re-examine deliberately or critically, usually with a view to approval or dissent; to analyse results for the purpose of giving an opinion

Action verb	**Students should be able to**
Recognise	identify facts, characteristics or concepts that are critical (relevant/appropriate) to the understanding of a situation, event, process or phenomenon
Reflect	to consider in order to correct or improve
Use	apply knowledge or rules to put theory into practice
Verify	give evidence to support the truth of a statement

Appendix 3

Suggested sample assessment items

To assist in interpreting the learning outcomes, the following examples illustrate written tasks that students should be able to complete having followed the course. These examples do not necessarily reflect the length or format of the questions on the final examination paper. Each exemplar is preceded by a table which links the sample item to the learning outcomes of the specification.

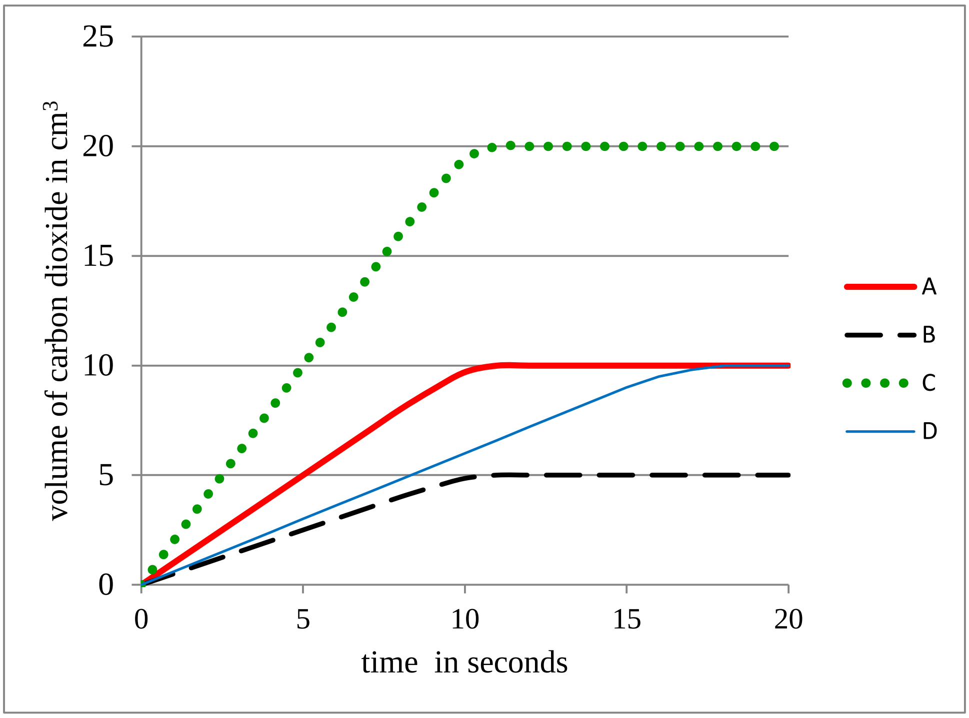
Sample item 1

Part	**Strand (learning outcome)**
a, **b**	Nature of science (3 + 4) Materials (7)
c, **d** and **e**	Materials (7)

In an experiment, Susan adds a solution of hydrochloric acid to solid chips of calcium carbonate. This causes a reaction that releases carbon dioxide gas. Susan records the volume of carbon dioxide released over time.

She does the experiment four times. The four sets of results are shown in the graph below, labelled **A**, **B**, **C** and **D**. Susan keeps the following variables fixed in all four cases:

- temperature
- pressure
- volume of hydrochloric acid
- concentration of hydrochloric acid.



(a) It says above that “Susan keeps the following variables fixed”.

What does the word “variable” mean here?

Answer:

____

____

(b) In an experiment, why is it important to keep some of the variables fixed?

Answer:

____

____

____

(c) The mass of calcium carbonate was something which Susan did **not** keep fixed. Which time did she use the <u>smallest</u> mass? Answer **A**, **B**, **C** or **D**. Explain your answer.

Answer: ☐

Explanation:

____

____

____

(d) Give one possible difference between the conditions used in case **A** and case **D**.

Answer:

____

____

____

(e) At the start of the reactions, which case showed the greatest *rate of reaction*?

Answer: ☐

Sample item 2

Part	Strand (learning outcome)
a	Nature of science (1 + 6)
b	Nature of science (6)
c	Nature of science (2 + 3)

The following is a news article from January 19th 2014:

Blue Monday is Year's Saddest Day

If you woke up feeling grumpier than usual this morning you're probably not alone, as experts reckon today is one of the gloomiest days of the year.

Researchers say the third Monday in January is when people are more unhappy than at any other time in the year.

Apparently it's all to do with the grey and depressing weather, breaking our New Year's resolutions and not having much cash to splash in the shops!

(a) Do you think this article is from a scientific journal or not? Explain your answer.

Answer:

____

(b) Does this article provide any *evidence* for the existence of 'Blue Monday'? Give reasons for your answer.

Answer:

(c) Outline a fair, scientific way to investigate if weather has an effect on people's moods?

Answer:

Sample item 3

Part	Strand (learning outcome)
a	Earth and space (1)
b	Nature of science (4)
c	Nature of science (4) Earth and space (3)
d	Physical world (2)
e	Materials (2 + 4)
f	Earth and space (3)
g	Nature of science (1)
h	Nature of science (9) Earth and space (8)

The table below shows data for some of the largest objects in our solar system, including the sun, the planets, some dwarf planets and some moons. In each case the radius, mass and surface gravities of the object are shown relative to those of the Earth. (For example, the Sun's relative radius of 109 means that its radius is 109 times the radius of the Earth.)

Object	Type of object	Relative mass	Relative radius	Surface gravity
Sun	Star	333000	109	28.0
Jupiter	Planet	318	11.0	2.53
Saturn	Planet	95.2	9.14	1.06
Uranus	Planet	14.5	3.98	0.90
Neptune	Planet	17.1	3.86	1.14
Earth	Planet	1	1	1
Venus	Planet	0.815	0.950	0.905
Mars	Planet	0.107	0.532	0.38
Ganymede	Moon of Jupiter	0.0248	0.413	0.15
Titan	Moon of Saturn	0.0225	0.404	0.14
Mercury	Planet	0.0553	0.383	0.38
Callisto	Moon of Jupiter	0.0180	0.378	0.126
Io	Moon of Jupiter	0.0150	0.286	0.183
Moon	Moon of Earth	0.0123	0.273	0.166
Europa	Moon of Jupiter	0.00803	0.245	0.134
Triton	Moon of Neptune	0.00359	0.212	0.0797
Pluto	Dwarf Planet	0.0022	0.186	0.062
Eris	Dwarf Planet	0.0027	0.182	0.0677
Titania	Moon of Uranus	0.00059	0.124	0.0385

(a) Name the object in our solar system that *Earth* travels around: ____________

Name the object in our solar system that *Titan* travels around: ______________

(b) Do you think that the objects in the table are listed in order of *mass*, in order of *radius* or in order of *gravity*?

Answer: ______________________

(c) Alex studies the table and says that as the *mass* of an object decreases, so does its surface gravity.

Do you agree with Alex? Explain your answer.

Answer (YES or NO): _____________

Explanation:

____

____

____

Bridget studies the table and says that as the *radius* of an object decreases, so does its surface gravity.

Do you agree with Bridget? Explain your answer.

Answer (YES or NO): _____________

Explanation:

____

____

____

(d) The *density* of an object is its *mass* divided by its *volume*. A scientist wishes to use the data in the table to calculate which of the planets has the greatest density. Explain how the scientist would do this.

Answer:

____

____

____

(e) Do you think the planet with the greatest density will be made of *gas*, like Jupiter, or made of *solid rock*, like Earth. Explain your answer.

GAS or ROCK: _______________

Explanation:

____

____

____

(f) Do you think that a person has the same *mass* on Mars as on Earth?

Answer (YES or NO): _____________

Do you think that a person has the same *weight* on Mars as on Earth?

Answer (YES or NO): _____________

Explain your answers.

Explanation:

____

____

____

Pluto was discovered in 1930. For years after that, scientists called Pluto a planet. However when scientists discovered that there were many other "small" objects orbiting the Sun, they no longer called Pluto a planet, but instead called it a *dwarf planet*.

(g) Explain why scientists sometimes change their ideas about the world around us.

Explanation:

____

____

____

____

____

____

(h) Give an account of the ethical issues which you think we should consider when we plan future exploration of the solar system.

Answer:

Sample item 4

Part	Strand (learning outcome)
a	Materials (4)
b	Materials (2)
c, **d**	Materials (5)

Lithium oxide is a chemical compound made from the metal lithium and the non-metal oxygen. When a piece of lithium is cut with a knife, it combines with the oxygen in the air to make the compound lithium oxide.

(a) How could you tell the difference between a *metal* and a *non-metal*?

Answer:

____

____

____

(b) Is the reaction between lithium and oxygen an example of a *physical* change or a *chemical* change? Explain your answer.

Answer (PHYSICAL or CHEMICAL): ____

Explanation:

____

____

____

How could you check if the reaction was a physical change or a chemical change?

Answer:

____

____

____

(c) Find lithium (Li) and oxygen (O) in the periodic table of the elements on page 79 of your *Formulae and Tables*.

What is the **number** of the group (column) that contains lithium? ______________

What is the **number** of the group (column) that contains oxygen? ______________

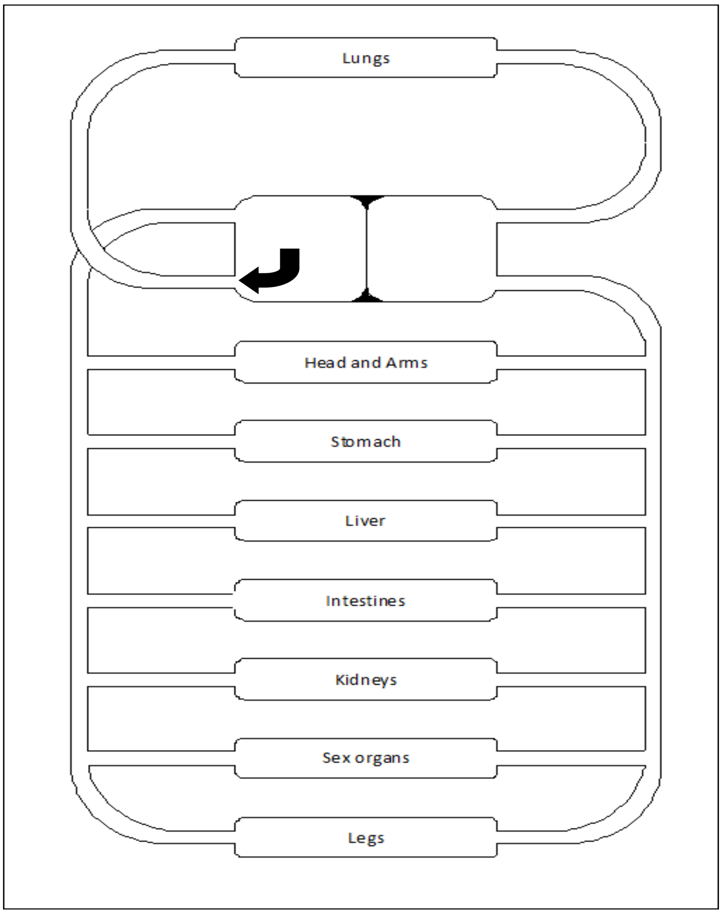
(d) Use your answers from part **(c)** to predict how many lithium atoms are needed to combine with one oxygen atom in lithium oxide.

Answer: ______________

Sample item 5

Part	Strand (learning outcome)
a, **b**, **c** and **d**	Biological world (4)
e	Biological world (4, 7)
f, **g**	Biological world (4)
h	Biological world (6)

The diagram below shows a model of the system which is used to move blood around the body.



(a) Name the organ which pumps blood around the body. ______________

(b) The arrow on the diagram shows the direction the blood is flowing in at that point. Draw **three** more arrows in different parts of the diagram to show what direction the blood is flowing there.

(c) Write the letter **G** in the diagram at a place where the blood *gains oxygen*.

Write the letter **L** in the diagram at a place where the blood *loses oxygen*.

Write the letter **W** in the diagram at a place where *waste* is removed from the blood.

Write the letter **N** in the diagram at a place where the blood takes in *nutrients*.

(d) One of the reasons we need our blood to move through our bodies is so that it can transport different substances to and from various parts of our bodies. State **one** other reason why we need our blood to flow.

Answer:

____

____

____

(e) Explain why it is important that our bodies get both *nutrients* and *oxygen*.

Answer:

____

____

____

____

____

(f) Write the letter **P** in the diagram at a place where your *pulse* could be taken.

(g) Why might your pulse increase while you are exercising?

Answer:

____

____

____

(h) Name one lifestyle choice that could cause your resting pulse to *decrease* over time.

Answer: ____

Sample item 6

Part	**Strand (learning outcome)**
a, **b**	Biological world (5)
c	Biological world (9)

The photograph is of the *blackthorn* tree which is found in many parts of the Irish countryside. The branches of the tree have sharp thorns. These make it difficult for animals to eat the fruit, which are called *sloes*.

(a) Are the sharp thorns of the tree an example of *adaptation*, *competition* or *interdependence*?

Answer: ________________________________

(b) When animals eat the sloes, they gain energy from the food. They also help to disperse the seeds of the plant which are inside the sloes. Is this an example of *adaptation*, *competition* or *interdependence*?

Answer: ________________________________

(c) We sometimes use sloes to make jam and alcoholic drinks. State one other benefit or use that we might get from the blackthorn tree.

Answer: ________________________________

Appendix 4

This Appendix sets out the NCCA's Work to date on potential assessment arrangements for Junior Cycle Science. Consultation on the assessment for certification arrangements is deferred until discussions take place between the Minister for Education and Skills and the teacher unions in October.

Work to date on potential assessment arrangements

Assessment for certification

Junior cycle science will have two assessment components in the assessment for certification: a school work component and a final assessment. The school work component will carry 40% of the marks available and the final assessment will carry 60%. The school work component comprises a scientific research report (scientific investigations/issues investigations) and a direct observation of students' practical work spread over the second and third years of junior cycle and will relate to the students' work during that time. Up to 10% of the overall marks will be awarded by direct observation of students engaging in practical work.

The assessment tasks in the school work component

Practical assessment linked to the development of their practical competence, procedural understanding, and ability to work with others, during practical activities.

Scientific research reports emerging through engagement with a broad range of scientific investigations and issues investigations. The students' reports may be presented in a wide range of formats.

Mark weighting for the assessment components

The following tables are predicted on the total mark available being 400.

Table 6: Breakdown of marks between school component and final assessment

School work components	40%	160 marks
Final assessment	60%	240 marks

Timing and mark weighting for the school work components

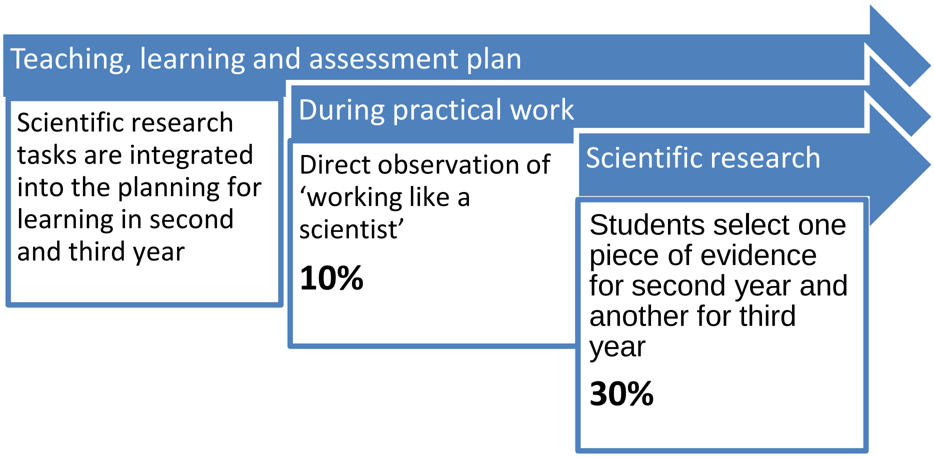
Table 7: Breakdown of marks between the school components

Component	Marks	Submitted	Moderation meeting
Practical assessment	40 marks	Not applicable	Not applicable
Scientific research	60 marks 60 marks	End of Year 2 Christmas to midterm Year 3	End of Year 2 Christmas to midterm Year 3

Rationale for the assessment tasks

Over the three years of junior cycle students will have many opportunities to enjoy and learn science. They will work like a scientist as they formulate scientific questions and hypotheses, initiate research, plan and conduct investigations, process and analyse data and information, evaluate evidence to draw valid conclusions, and report and reflect on the process. Students will collaborate as they prepare scientific communications for a variety of purposes and audiences. They will learn about and make informed decisions about their own health and wellbeing, and issues relating to social and global importance. Through these activities they will develop their science knowledge, understanding, skills, and values, thereby achieving the learning outcomes across the strands. The assessment tasks link to important aspects of that development and relate to priorities for learning and teaching.

Figure 3: The integration of the school component assessment into relevant classroom learning



Scientific research reports

Investigating in science and communicating in science are vital to working like a scientist. Students need to develop a sense of what is appropriate for scientific investigation and research, plan and conduct investigations and research issues, process and analyse data and information, draw evidence based-conclusions, evaluate the process, and prepare scientific communications. This is best done over time and with supportive feedback and scaffolding from the teacher. This assessment task offers students the chance to celebrate their achievements as creators of scientific research reports by selecting a problem or issue to investigate. In the majority of cases, the work done by the student will arise from material and tasks encountered in class, or with the agreement of the teacher, the student may select other material relevant to the learning outcomes of junior cycle science.

The range of assessment methods that can be used to engage students in scientific research are set out in table below.

Table 8: Range of assessment methods used to engage students in scientific research

Methods	Purpose	Sample assessment task
Scientific investigation	This method is used to assess students' ability to conduct an investigation, generate questions, and generate and analyse primary data.	What factors affect the biodiversity of the school yard? Devise and test a model of the relationship between the volume of a bubble and speed of the bubble. Design and test the effectiveness of a container to keep an ice-pop cool.
Issues investigation	This method is used to assess students' ability to research socio-scientific issues, ask questions, collect, analyse and draw evidence-based conclusions about secondary data and information, and to make appropriate recommendations.	What role should wind farms play in meeting Ireland's current and future energy needs? Evaluate media-based arguments for exploring Mars. Research issues concerning use of tap water for watering plants.

The presentation formats for each of the above methods can include the following (this is not an exhaustive list):

- a hand-written/ typed report
- computer-generated simulations
- multimodal presentation
- webpage
- model building
- podcasts.

The assessment tasks will be spread over the second and third years of junior cycle and will relate to the student's work during that time.

Students select the two pieces of work that they consider will best illustrate their learning. At least one sample must be a scientific investigation.

Students should receive a copy of the features of quality as early as possible, so that they are aware of what they need to generate work of the highest possible standard. The selected pieces of student work should be presented as a draft to their teacher during the ongoing assessment, learning and teaching activities. Feedback, in the form of prompts for improvement, on work which is to be presented for certification can be given to students. This must be general rather than specific. Students can use this feedback to improve the work that they present for certification. It is also acceptable and in some respects encouraged that the evidence of learning presented for assessment could be used as part of a student's entry to a local or national science fair.

Assessing the scientific reports

Features of quality for a scientific investigation

Key features of quality designed to support student and teacher judgement in assessing a scientific investigation are presented in Table 9 below.. The features of quality are the criteria used to assess the pieces of student work. Students' progress through the task is assessed in four performance aspects of a scientific investigation: questioning and predicating, planning and conducting, evaluating, and reviewing. For each aspect there are five hierarchical sets of features of quality.

Table 9	Distinction	Higher merit	Merit	Achieved	Partially achieved
	The student work has the following features of quality:				
Questioning and predicting	Poses question and provides a clear description and comprehensive explanation of scientific knowledge to propose a testable hypothesis.	Poses question and refers to scientific knowledge to form a testable hypothesis.	Poses question, forms a testable prediction and justifies it by referring to common sense or previous experiences.	Selects a question to be investigated and makes a prediction without any justification.	Use of given investigation question.
Planning and conducting	Considers all relevant variables and explains how reliability and fairness are considered. Presents a full risk assessment identifying ways of minimising the risks. Describes the method and equipment used to systematically and accurately collect and record reliable data, in a manner that could be easily repeated. Records an adequate amount of good quality data with regular repeats and appropriate handling of outliers. Preliminary work is included to confirm or adapt the range and number of measurements to be made.	Describes reliability and fairness considerations. Correctly identifies safety and/or ethics considerations and suggests some precautions. Describes the method and equipment used to accurately collect and record reliable data, in a manner that could be easily repeated. Records an adequate amount of good quality data with regular repeats.	Correctly identifies safety and/or ethics considerations. Describes the method and equipment used to collect and record relevant data, showing some understanding of the need for repeatability. Records an adequate amount of data.	Describes the safe use of equipment to collect and record a limited amount of data.	Safe, directed use of equipment to collect and record data.

Processing and analysing	Presents data in the most appropriate way to indicate the spread of data, using relevant scientific terminology and representations. Considers critically the repeatability of the data, accounting for any outliers. Provides a clear and comprehensive description of the relationships between the variables. Provides a comprehensive and logically-sequenced conclusion supported by the data and uses relevant science knowledge to assess whether the hypothesis has been supported or to suggest how it should be modified to account for the data.	Displays data on tables and graphs, correctly selecting scales and axes, or constructs detailed charts or diagrams. Identifies obvious inconsistencies in data, or justifies a claim that there are no inconsistencies. Describes the relationships between the variables. Draws a conclusion consistent with the data and uses relevant science knowledge to assess whether the hypothesis has been supported by the conclusion.	Displays data on simple tables, charts or graphs, allowing for some errors in scaling or plotting. Identifies obvious inconsistencies in data, or justifies a claim that there are no inconsistencies. Draws conclusions and comments on whether the conclusion supports the prediction or hypothesis.	Displays a limited set of data in tables, charts or graphs using given axes and scales. Identifies simple relationships and states a conclusion but without reference to the data.	Restatement of given information and data.

Reflecting	Describes in detail the strengths and weaknesses of their own investigations, including a critique of the data-gathering procedures in order to recognise limitations to the claims that can be made from the data. Describes appropriate improvements or explains fully why no further improvements could reasonably be achieved.	Identifies the strengths and weaknesses of the investigation and suggests appropriate improvements, or explains why the data-gathering procedures were of sufficient quality.	Identifies some features of the investigation that could be improved and suggests improvements.	Identifies a feature of the investigation that could be improved and suggests an improvement.	Identifies a feature of the investigation that could be improved.

Features of quality for an issues investigation

Key features of quality designed to support student and teacher judgement in assessing an issues investigation are presented in Table 10 below.. The features of quality are the criteria used to assess the pieces of student work. Students' progress through the task is assessed in three aspects of an issues investigation: initiating research, reporting, and evaluating. For each aspect there are five hierarchical sets of features of quality.

Table 10	Distinction	Higher merit	Merit	Achieved	Partially achieved
	The student work has the following features of quality:				
Initiating research	Chooses own issue and question, and finds information about an issue from a large number of varied and balanced sources. Expert advice sought, if appropriate. A complete reference list is given. The reliability and quality (relevance, accuracy and bias) of the sources is discussed.	Chooses own issue and question, and finds a good variety of balanced sources of information and advice about an issue. A complete reference list is given. The reliability and quality (relevance, accuracy and bias) of the sources are evaluated.	Chooses their own issue and finds some useful sources of information. The reference list is incomplete; some details are missing. Some consideration given to reliability and/or quality (relevance, accuracy and bias) of the sources.	Chooses their own topic but had to be directed to sources of information. Very few sources of information are used and there is very little evidence of what the sources are. The reliability and quality of the sources are not evaluated.	Does not choose own issue, uses a given investigation question, and had to be directed to sources of information. Accesses information from predominantly one source.
Reporting	Several sides of the argument and the relevant science are explained in detail. Inconsistencies in the findings are identified. Presented using relevant scientific	Detailed and relevant information on the findings. Presented using relevant scientific terminology and representations, in a well-structured report	A good description of the findings but lacks detail about the scientific explanations. Presented using relevant scientific terminology and	Some good descriptions of the findings but some irrelevant information is included in a report that has some structure.	A lot of irrelevant information included and there is little or no structure to the report.

	terminology and representations which helps to explain the information in a report that is very well-structured and clear and easy to read.	that is clear and easy to read.	representations, in a structured report.		
Evaluating	All the information evaluated and linked to the original question. All sides of the argument are reviewed using science explanations and an understanding about science. A personal view is developed, which is justified by referring to the evaluated information.	Most information is evaluated using science knowledge and an understanding about science. The different sides in the argument are considered and compared. A personal view is given with the explanation linked to the argument.	Some information is evaluated using science knowledge and an understanding about science. A personal view is given, with a little bit of explanation.	Some discussion of the information used and why it is important yet some evidence is ignored, or discounted. A personal view emerges that is a biased or incomplete answer to the original question.	Little discussion of the information used and why it is important. Personal view given is just a restatement of information used.

Marking the scientific reports

Each of the scientific research components are marked at a common level out of a total of 120 marks. The marking schemes below draw directly from the features of quality for each type of investigation.

The awarding of marks in each row of the grid is based on the professional judgement of the teacher. Each of the sets of features of quality are considered in turn, working up from the partially-achieved level to the highest grading level that fully matches the student's work. Once a level has been reached that doesn't fully matched the work, no higher levels are considered.

Each level within an aspect of the investigation covers a range of two marks. The higher mark is awarded when the student's work *fully* matches the features of quality for that level. The lower mark is awarded when the student's work has *partially* matched the features of quality for that level, but has exceeded the features of quality set out in the preceding, lower level. Where there is no evidence of engagement with an aspect of the investigation, or the response is insufficient to award the marks for partially achieved, a mark of zero is awarded for the aspect.

Table 11: Marking the scientific investigation

	Distinction	Higher merit	Merit	Achieved	Partially achieved
Questioning and predicting	(10/9)	(8/7)	(6/5)	(4/3)	(2/1)
Planning and conducting	(20/19)	(17/16)	(15/12)	(11/9)	(8/6)
Processing and analysing	(20/19)	(17/16)	(15/12)	(11/9)	(8/6)
Reflecting	(10/9)	(8/7)	(6/5)	(4/3)	(2/1)

Table 12: Marking the issues investigation

	Distinction	Higher merit	Merit	Achieved	Partially achieved

Initiating research	(20/19)	(17/15)	(14/12)	(10/8)	(7/6)
Reporting	(20/19)	(17/15)	(14/12)	(10/8)	(7/6)
Evaluating	(20/19)	(17/15)	(14/12)	(10/8)	(7/6)

Practical assessment

Throughout junior cycle, students are provided with opportunities to work as a scientist in the laboratory and/or off-site. Students use equipment to collect, interpret and validate evidence; they manage themselves to work efficiently and safely, and collaborate with others. The development of manipulative, procedural and cognitive skills through practical activities that foster investigation, imagination, curiosity and creativity is central to the aims of junior cycle science.

The practical assessment enables students to demonstrate the development of their practical competence, procedural understanding, and their ability to work with others, in a way that cannot be assessed in the written examination. The practical assessment is an enabling assessment that focuses on supporting students in these areas of development.

The practical assessment task assesses students on their ability to

- use equipment to collect data and observations
- manage themselves to work efficiently and safely
- collaborate with others on a task.

Students who have not developed practical competence and procedural understanding during the course of first and second year will not be able to complete the assessment successfully.

Assessing the practical assessment component

Features of quality for the practical assessment

Key features of quality designed to support student and teacher judgement in assessing the practical assessment component are presented in Table 13 below. The features of quality are the criteria used to assess the student work. Students' progress through the task is assessed in two aspects of practical assessment: safety and use of equipment, and collaboration. For each aspect there are three hierarchical sets of features of quality.

Table 13	Distinction	Merit	Partially achieved
	The student work has the following features of quality:		
Safety and use of equipment (20m-direct observation)	Correctly selects appropriate equipment to systematically and accurately collect and record reliable data. Safely assembles and uses appropriate equipment. Recognises when personal safety is threatened and responds appropriately.	Selects equipment to collect and record relevant data. Safely uses appropriate equipment, but demonstrates some difficulty in assembling the apparatus. Recognises when personal safety is threatened.	Directed use of equipment to collect and record data. Occasionally recognises when personal safety is threatened.
Collaboration (20m-direct observation)	Seeks out different perspectives, listens actively and considers them carefully. Asks well thought-out questions to challenge assumptions and ideas, both personal and those of others, and facilitates in developing a group consensus. Confidently, succinctly and clearly expresses opinions, showing respect for different points of view. Shows flexibility and willingness to adjust own thinking in light of new information as the group seeks to achieve a common goal. Takes on different roles within groups and contributes to decisions as part of the group.	Listens actively to different perspectives when considering options. Questions assumptions and ideas, both personal and those of others. Confidently expresses opinions, showing respect for different points of view. Makes compromises to achieve a common goal. Takes on similar roles within groups but contributes to decisions as part of the group.	Listens to others some of the time. Accepts ideas on authority and does not suspend judgement. Limited expression of opinions. Assists group but does not take on responsibilities of a particular role in the group.

Marking

The practical assessment is marked at a common level out of a total of 40 marks. It is conducted as a model of punctuated direct assessment over the second and third year of junior cycle. At the end of Year 3, the teacher makes an on-balance judgement of the overall quality of a student's practical work.

It is important that the gathering of evidence to support teacher judgement is manageable. For example, before an activity a teacher may decide on one or two particular practical skills they want to assess that day. During practical activities, the teacher gives all students the attention they would normally receive. By the end of the class the teacher records how they have seen students perform that day. The teacher is not expected to mark all students for every activity: they may choose to focus on three students, but over the course of second and third year all students should be evaluated in this way the same number of times. At the end of Year 3, the teacher is then in a position to make an on-balance judgement of the overall quality of a student's practical work based on the features of quality. Students will complete the practical assessment throughout the second and third year of post-primary education.

The awarding of marks in each row of the grid is based on the professional judgement of the teacher. Each of the sets of features of quality are considered in turn, working up from the partially-achieved level to the highest grading level that fully matches the student's work. Once a level has been reached that doesn't fully match the work seen, no higher levels are considered.

Each level within an aspect of the practical assessment covers a range of two marks. The higher mark is awarded when the student's work *fully* matches the features of quality for that level. The lower mark is awarded when the student's work has *partially* matched the features of quality for that level, but has exceeded the features of quality set out in the preceding, lower level. Where there is no evidence of engagement with an aspect of the investigation, or the response is insufficient to award the marks for partially achieved, a mark of zero is awarded for the aspect.

The following grids should be used as reference points when allocating marks for performance-based assessment.

Table 14: Marking of laboratory and collaborative skills

	Distinction	Merit	Partially achieved
Safety and use of equipment	(20/18)	(15/13)	(8/6)
Collaboration	(20/18)	(15/13)	(8/6)

Moderation

The process will be conducted in accordance with the guidelines set out in the Assessment and Moderation Toolkit produced by the NCCA.

In the particular case of the practical assessment in junior cycle science, there will be no moderation of the 40 marks awarded directly by the teacher for safety and use of equipment, and collaboration.

In advance of the moderation meeting, the teacher

- marks all the students reports by reference to the relevant features of quality and marking grid
- brings two examples at or just above each grade boundary (No grade, Partially achieved, Achieved, Merit, Higher merit, Distinction). Where no booklet has been awarded Not achieved, the teacher selects the booklet with the lowest mark as one of the examples; where no booklet has been awarded with Distinction, the teacher selects the booklet with the highest mark as one of the examples.

The final assessment

The final assessment will carry 60% of the marks available. There will be one examination paper at a common level.

The final assessment	
Students will sit a two-hour examination. They will be required to engage with, demonstrate comprehension of, and provide written responses to stimulus material. The content and format of the final examination may vary from year to year. In any year, the learning outcomes to be assessed will constitute a sample of the outcomes from the tables of learning outcomes.	The examination takes place at the end of third year and will be offered at a common level. Initially, the final assessment and marking scheme for grading purposes will be prepared by the State Examinations Commission. The examination will be corrected by the class teacher and a moderation meeting will take place at the end of third year.

The material on junior cycle science included in the Assessment and Moderation Toolkit will contain details of the practical arrangements relating to the assessment of the school work component including, for example, the suggested length and formats for student pieces of work, and the process of school-focused moderation involved.

Reasonable accommodations

Where a school judges that a student has a specific physical or learning difficulty, reasonable accommodations may be put in place to remove as far as possible the impact of the disability on the student's performance in the assessment task, so that he or she can demonstrate his or her level of achievement. The accommodations (e.g. the use of Irish Sign Language, support provided by a Special Needs Assistant, or the support of assistive technologies) should be in line with the arrangements the school has put in place to support the student's learning throughout the school year.